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Pathway Selection by an Active Particle

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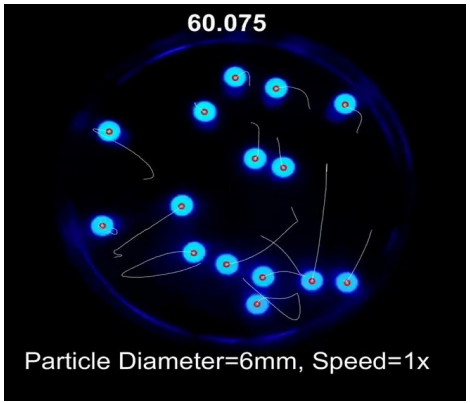
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1) Dr. Anjuman Ara Khatun, Postdoc, IIT Bombay
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Self propelled particles (SPP) or Active particles

- Capable of harvesting energy from their immediate environment and can convert it into mechanical drive.
- This mechanism provides essential motion and enables them to propel in a certain direction.



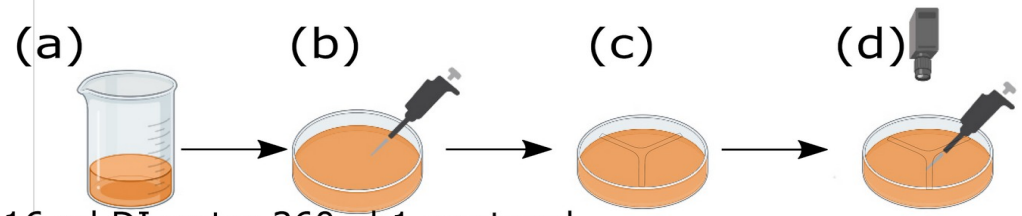




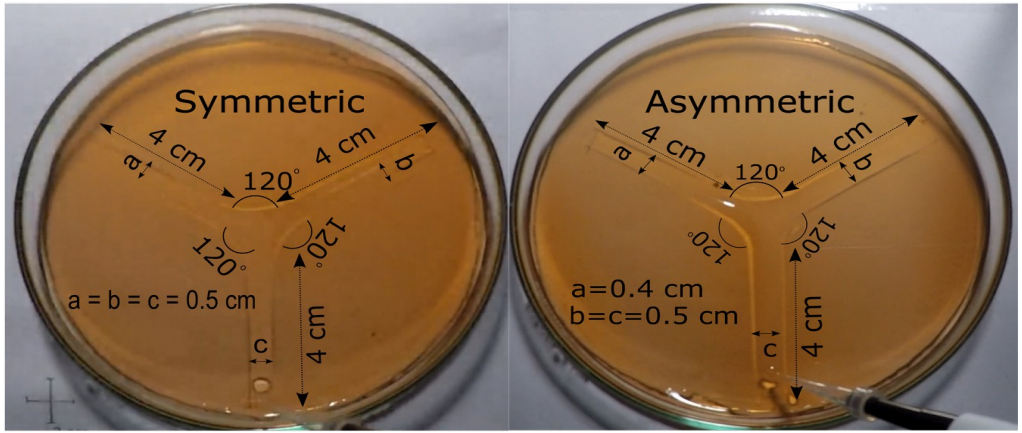
I. Tiwari, et al., ***Soft Matter*****,** 2021,17**,** 2865.
J. Sharma, et al., ***Physical Review E****, 2019*, *99*(1), 012204.
T. Roy, et al., ***Physical Review E,*** 2022,106, 034614.

Pathway selection by an active droplet

Experimental Protocol & Challenges



16 ml DI water 360 µl 1-pentanol
+ 80 µl Ferroin added



Challenges & sensitivity

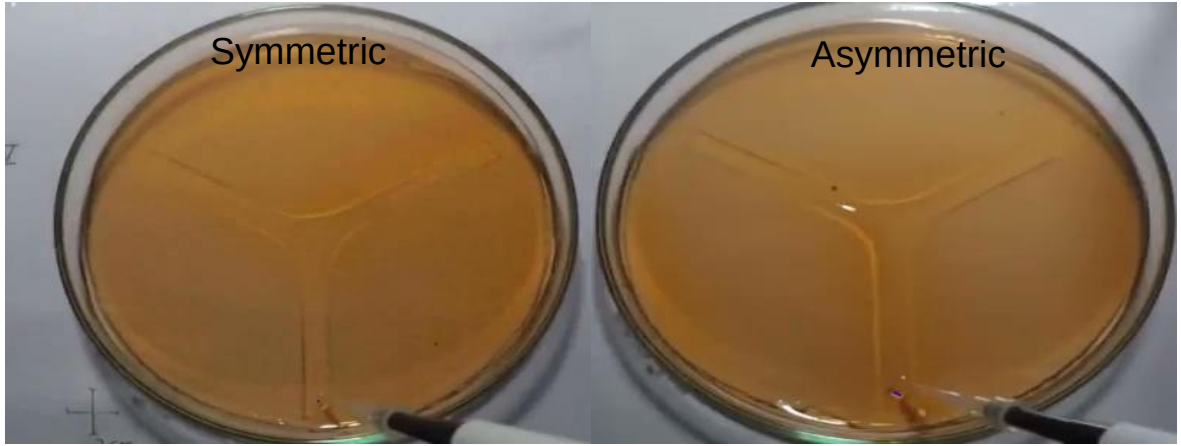
1. The approximate time of a single experiment is ~ 2-4 hours.

2. Stabilization of an active droplet was very sensitive and depends on many external factors such as Temperature~(21-25°C), Humidity ~ (50), contamination (oil, dust), smoothness of the boundary, and thickness of the channel (lamination sheet).

3. The accurate amount of initial dissolution of 1-pentanol plays a big role in the stabilization of the drop.

Geometrical pathway selection (sensing)

Left=60 %,
Right = 40%

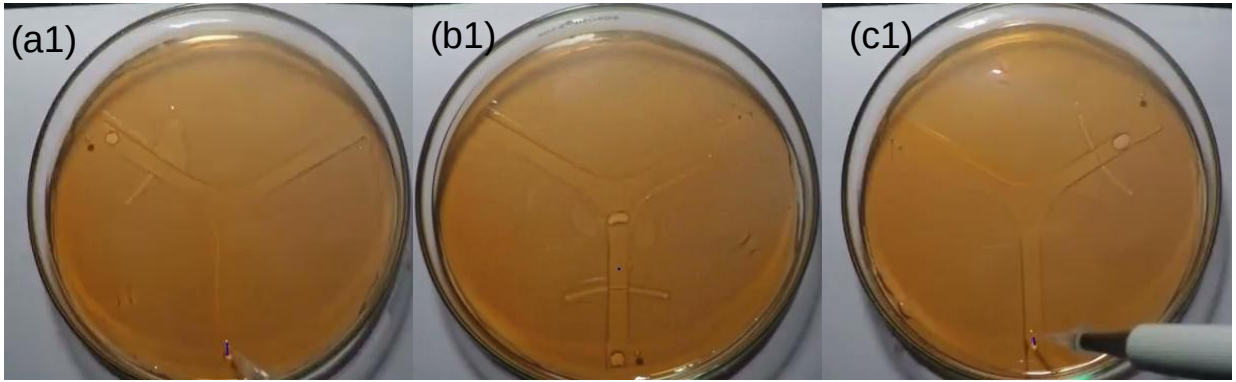


Narrow=20 %,
Wide= 80%

Senses geometrical asymmetry with ***80%*** accuracy.

Tracking of a droplet was done by IMAGEJ software.

Chemical pathway selection (sensing)

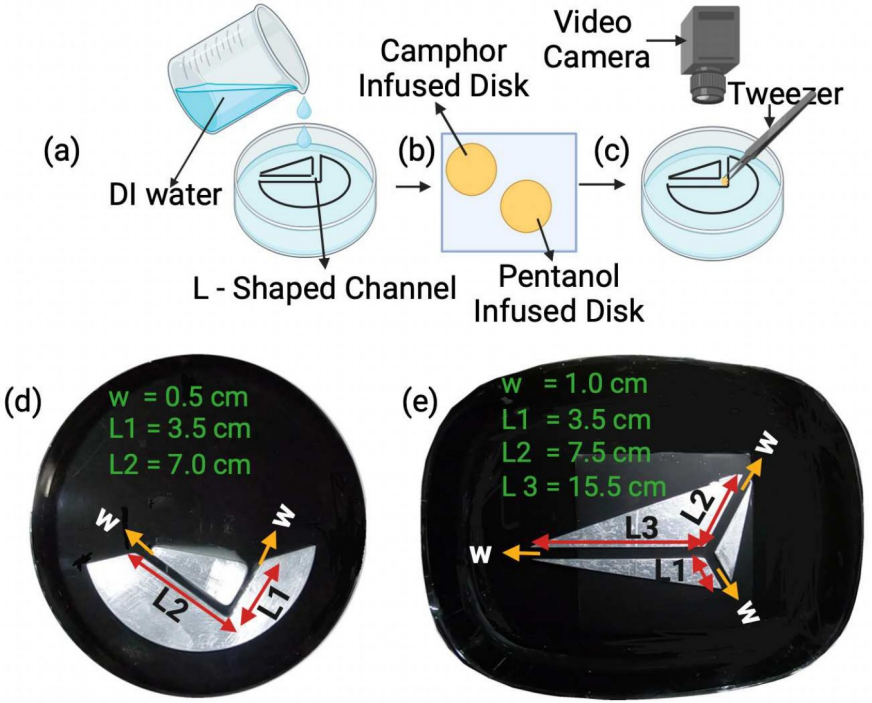


Senses chemical asymmetry with ***100%*** accuracy.

Conclusion: Free drop does not visit arm having the fixed drop.

Selection of Shortest Path

Setup



Disc Size: 0.6 cm and 0.3 cm Temperature: (21-25°C)

Experiments were performed by Anjuman Ara Khatun

Experimental Results

Two Path Channel (L Shaped)

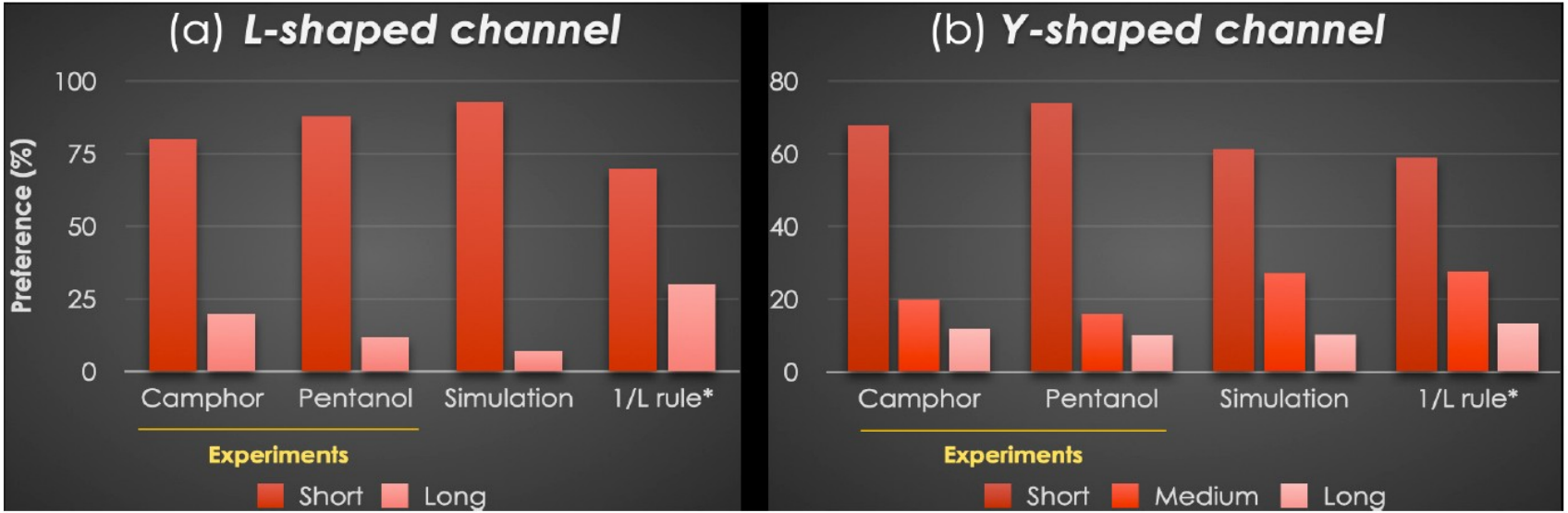


Three Path Channel (Y Shaped)

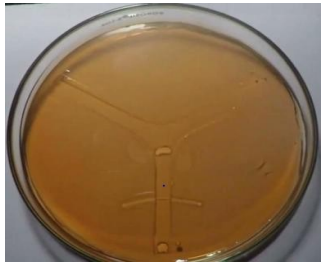


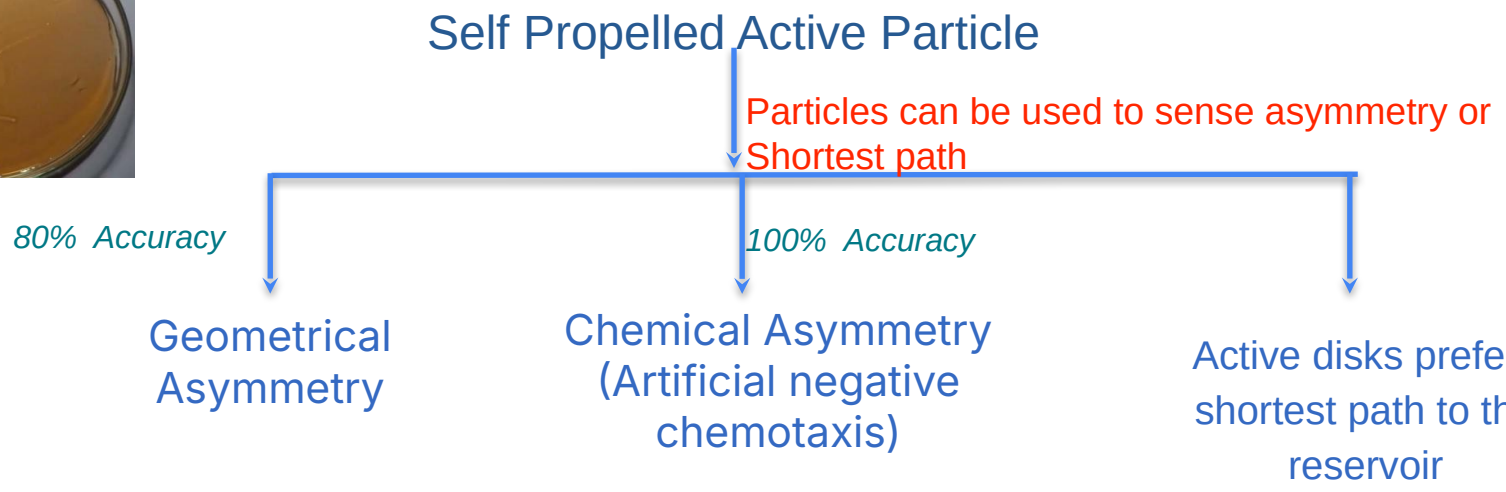
Experiments were performed by Anjuman Ara Khatun.

Analysis of experiments and simulations of pathway-selection



Conclusions & Future Directions





1) ***S. Dixit, A. Chotalia, S. Shukla, T. Roy, and P. Parmananda,*** **Pathway selection by an active droplet. *Soft Matter*, (2023).**
2) ***A. A. Khatun, A. Chotalia, K. Das, S. Dixit, and P. Parmananda, Surface tension gradient invoked path selection, Submitted.***

Statistical Analysis

TABLE I. Comparison of the ratio of widths of arms, the ratio of probability of the drop selecting two arms and the p-values.

Channel	Nature of Study	Observation[a]	$w_{\text{wider}}/w_{\text{narrower}}$	$p_{\text{wider}}/p_{\text{narrower}}$ [b]	p-value	Drop has preferred path
Symmetric	Experiment	30L + 20R	1.00	1.50	0.2	No
Symmetric	Simulation	51L + 49R	1.00	1.04	0.92	No
Asymmetric	Experiment	40W + 10N	1.25	4.00	2.4×10^{-5}	Yes
Asymmetric	Simulation	83W + 17N	1.25	4.88	1.3×10^{-11}	Yes

[a] L: Left and R:Right; W: Wide and N: Narrow
[b] In case of equal widths, the higher probability is assigned to p_{wider}

Statistical analysis validates experimental results.