The kinematics of active liquid crystal skyrmions

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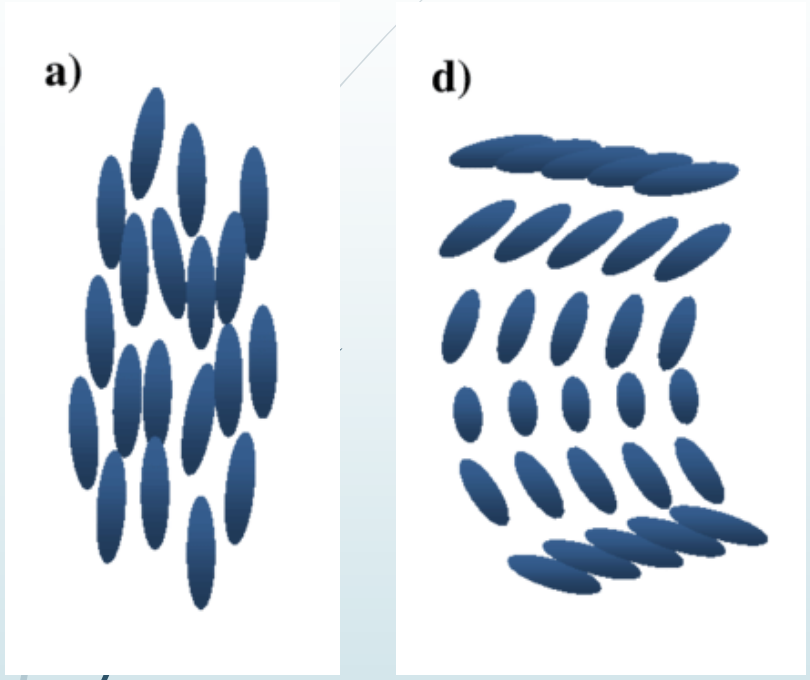
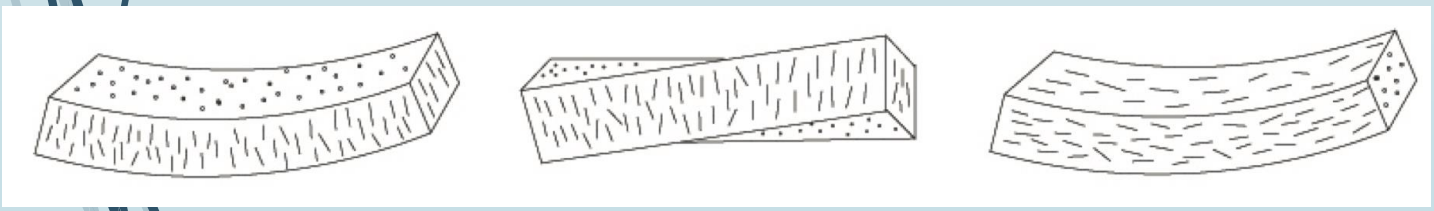
Liquid Crystals: Cholesteric Nematics



Left: Schematic of liquid crystal phases.

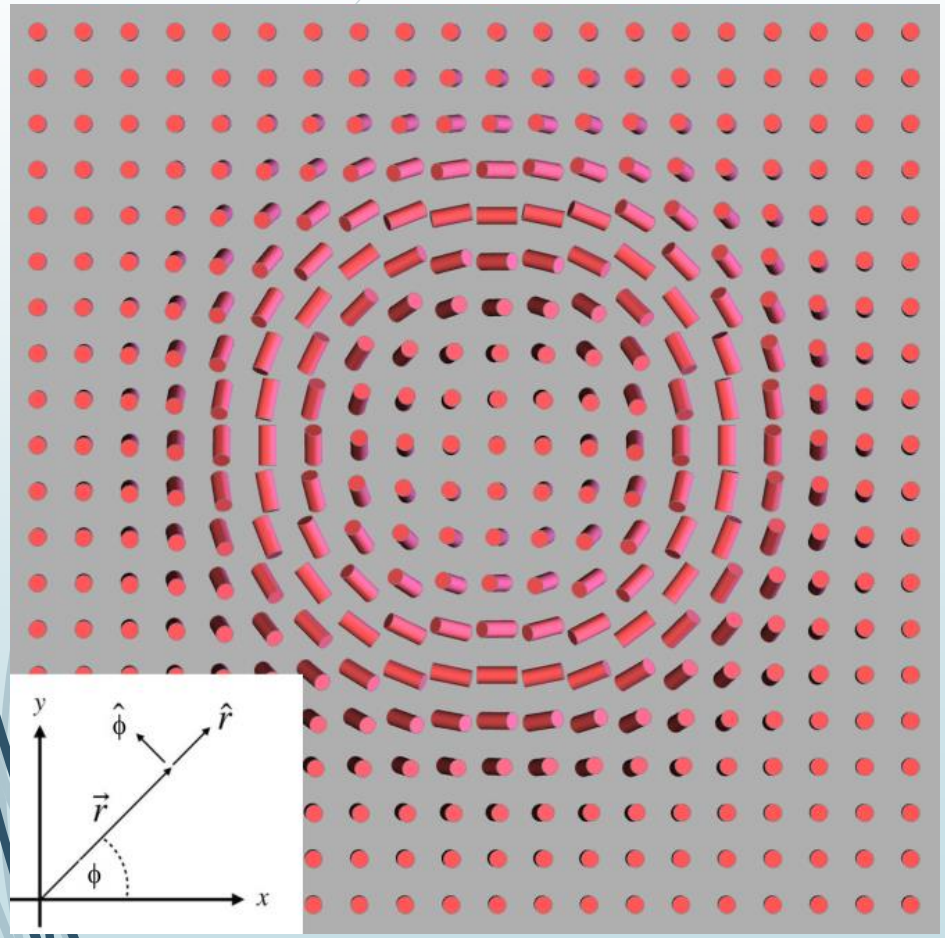
a) nematic phase
d) cholesteric phase

Above: Liquid crystal display . Changing molecular orientation requires little energy



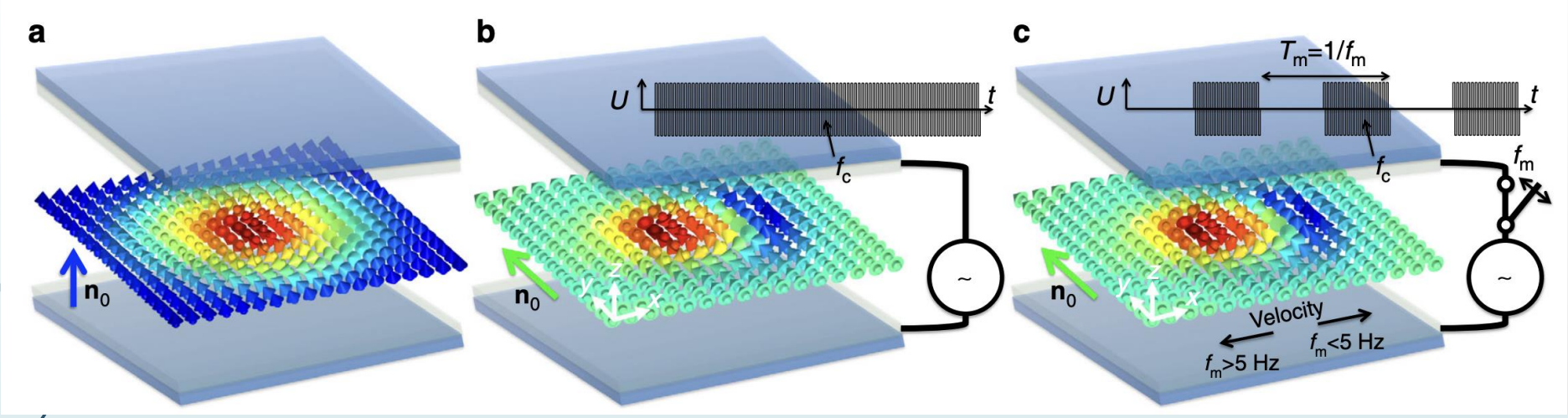
Left: Distortion modes of nematic LC. The Frank-Oseen elastic free-energy yields the energy of the system associated with these distortions.

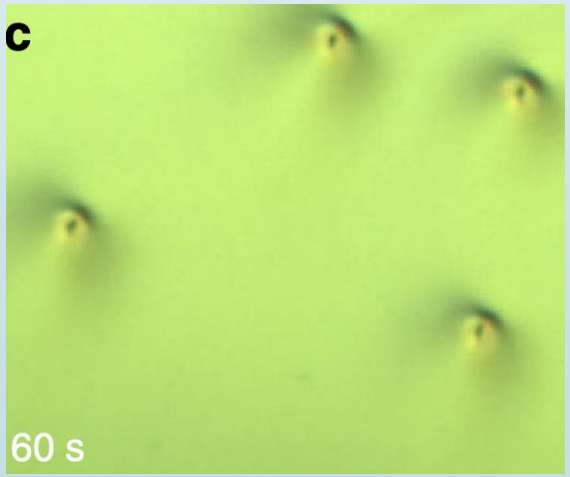
Skyrmion



- A cholesteric liquid crystal under confinement can have **frustration due to anchoring conditions**.
- Skyrmions can locally release some of that frustration.
- Their topological charge is conserved, for discontinuities in the director field have prohibitive energy costs.

Motivating experiment





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Top: Schematic of experimental setup and slice of director configuration.

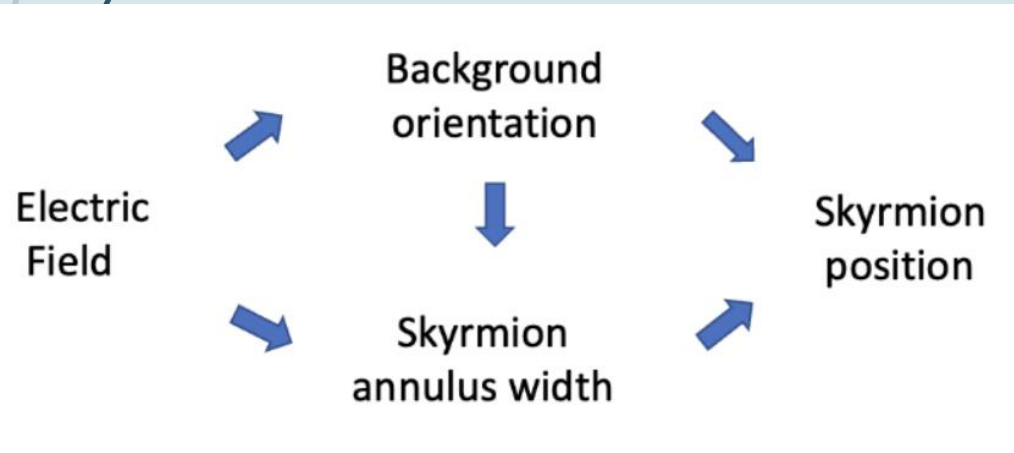
Left: Photograph of many skyrmions.

Coarse-grained model

$$n_x(\vec{r};\vec{r_s}=(0,0),n_{\hat{BG}}=\hat{z})=\sin\left(f(\frac{\rho-1}{\xi})\right)\cos(\phi+\phi_0)$$

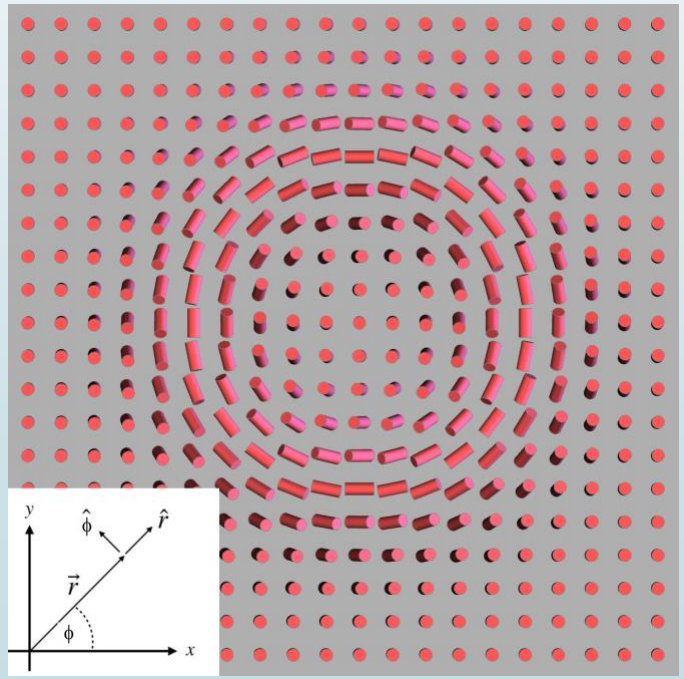
Top: Ansatz for the skyrmion.

Bottom: Relationships between external field and dynamical variables in the system of ODE's deduced from the ansatz.

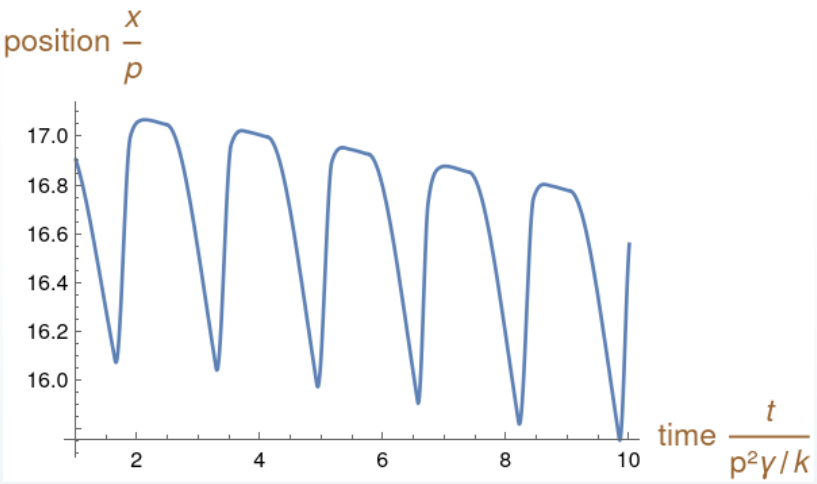


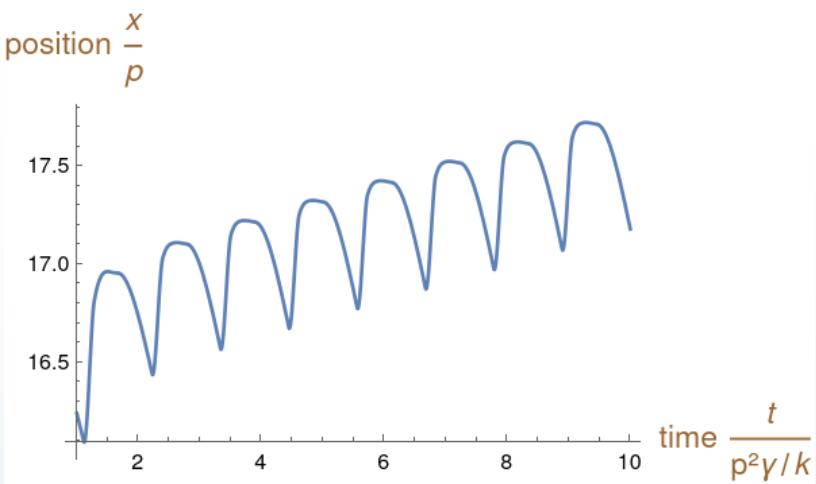
Dynamical variables:

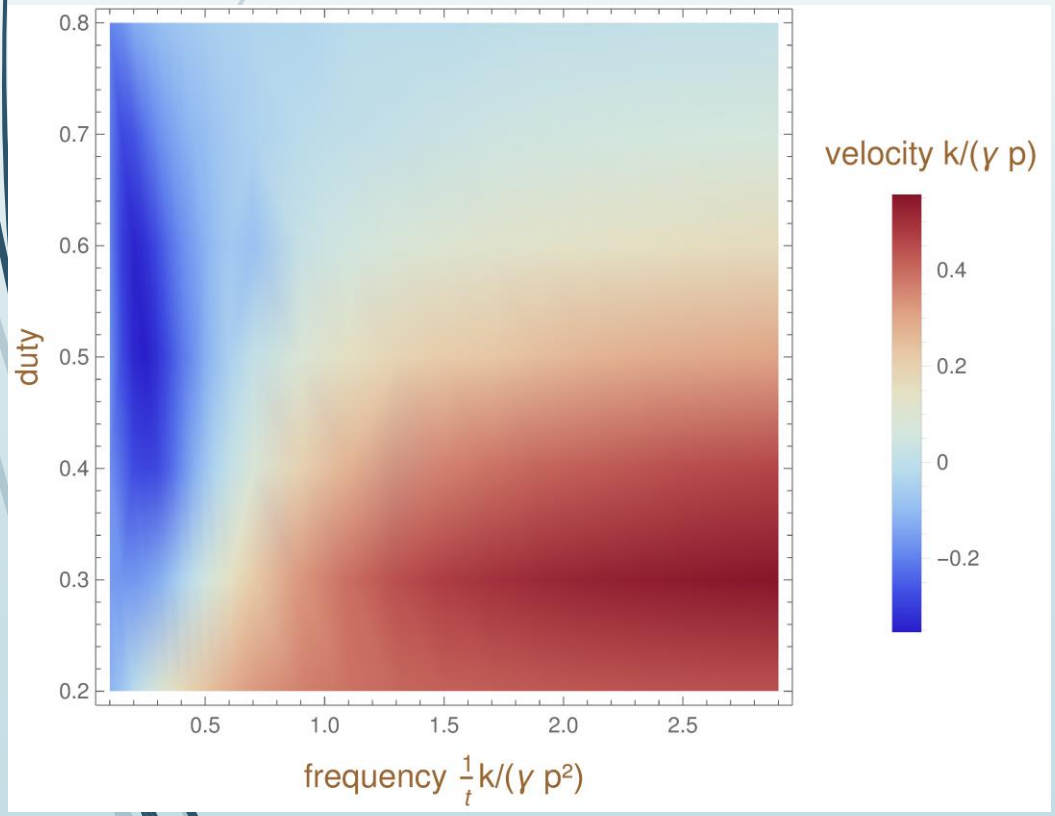
1. position of the centre $\boldsymbol{r_s}$;
2. background director $\boldsymbol{n_{BG}}$,
3. characteristic size ξ.

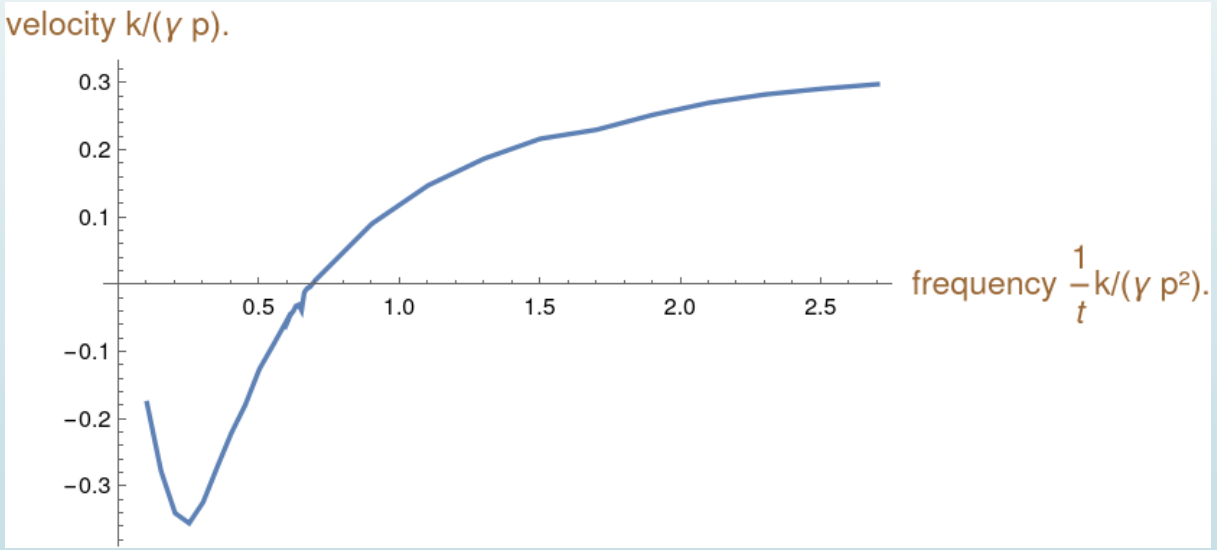


Results



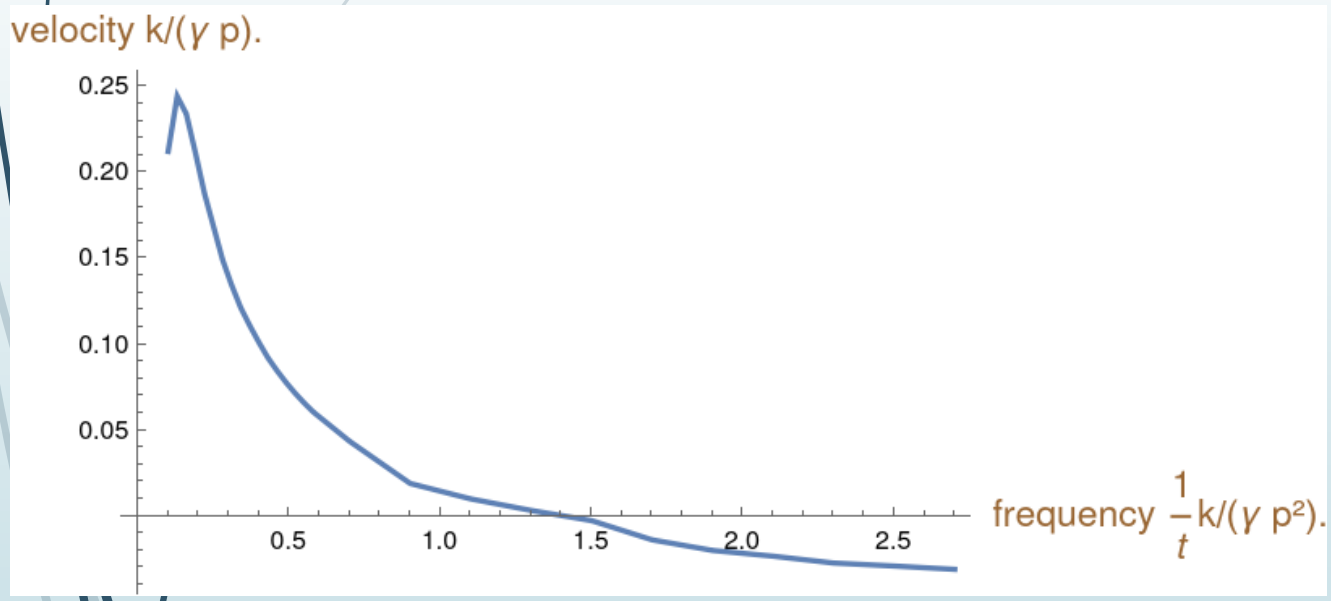




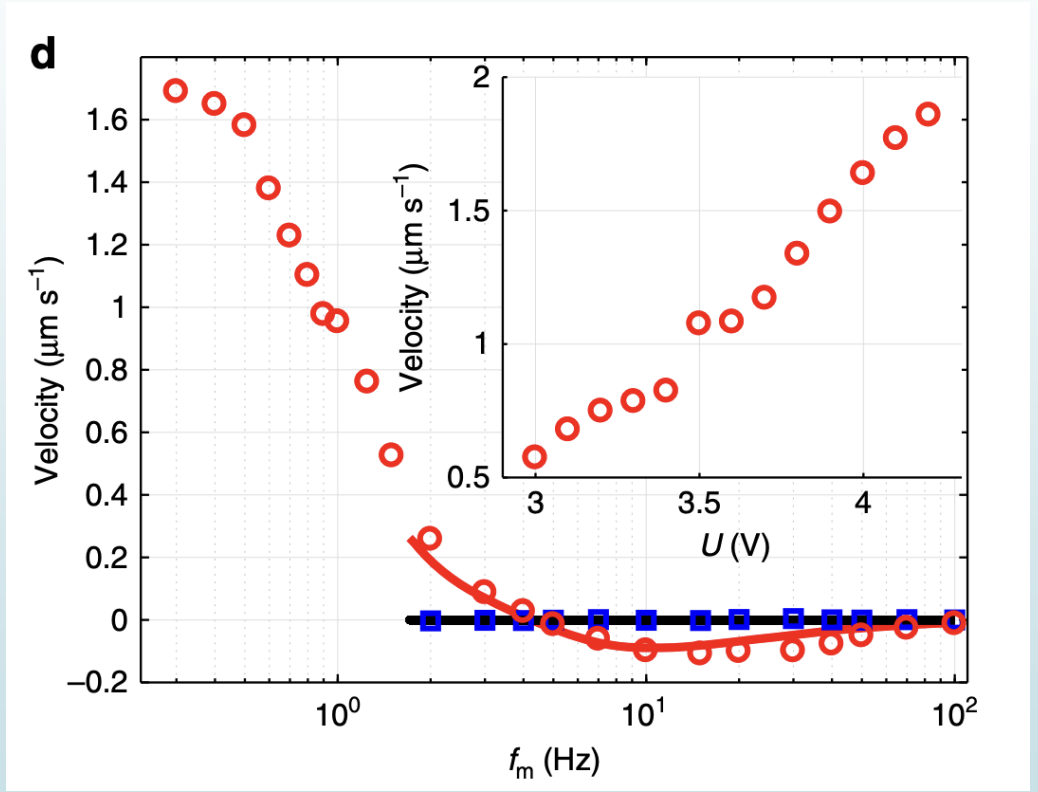


Top: Cross section of left density map, at duty=0.5

Comparison to experiments



Top: Velocity as a function of frequency for duty fixed at 75%, the same used in the experimental results on the right.



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Key Ideas

- Skyrmions's topological charge confers them stability.
- A coarse-grained model of the kinematics is required to simulate large numbers of skyrmions.
- A simple ansatz for the skyrmion shape is able to capture some of the complexity of the real system.

Thank you for your attention
Questions?