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Dissipative Solitons in Nematic Liquid Crystals

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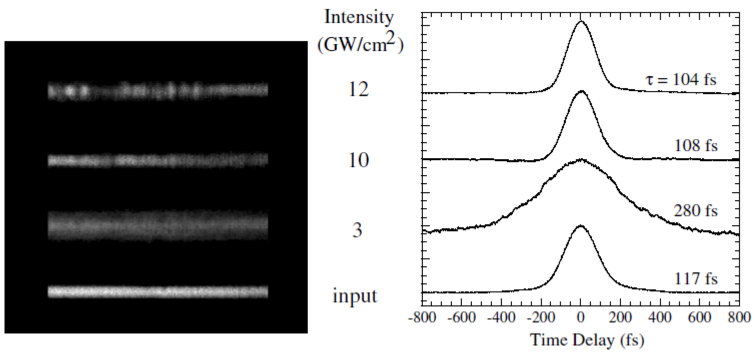
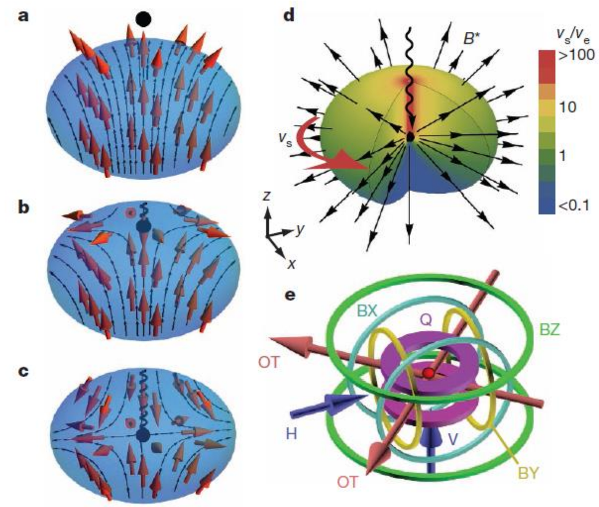
2020.11.10

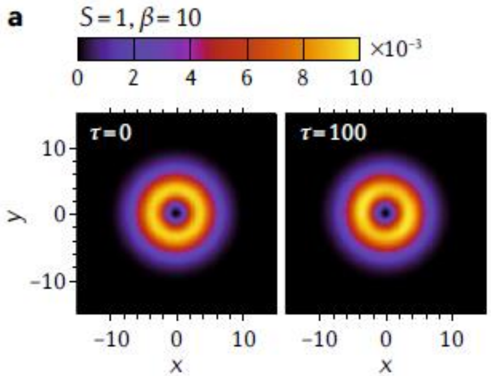
1、Solitons in Physics



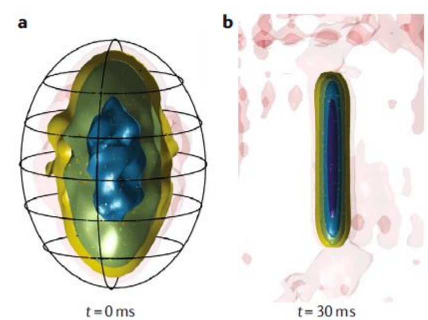
Experimental observation of Spatiotemporal optical solitons.
BA Malomed, et al., J. *Opt. B*, 2005, **7**, R53-R72.



Schematic representation of Dirac monopoles in a synthetic magnetic field.
MW Ray, et al., *Nature*, 2014, **505**, 657.

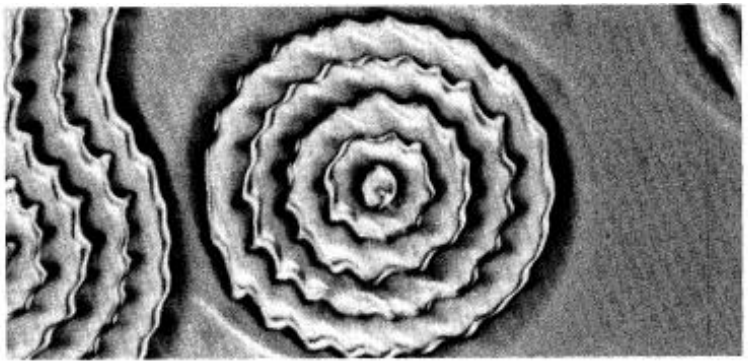


Vortex soliton in the binary Bose-Einstein condensates coupled by a microwave field.
J Qin, et al., *Phys. Rev. A*, 2016, **94**, 053611.



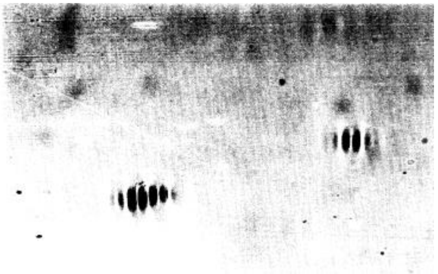
Self-sustained quantum droplet in condensate of Dy atoms.
D Baillie, et al., *Phys. Rev. A*, 2016, **94**, 021602R.

1、Solitons in Liquid Crystals



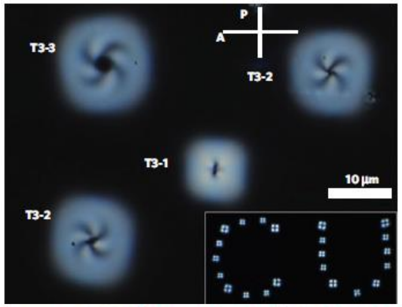
Dissipative solitons in a nematic LC generated by a rotating magnetic field.

KB Migler, et al., *Phys. Rev. Lett.*, 1991, **66**, 1485.



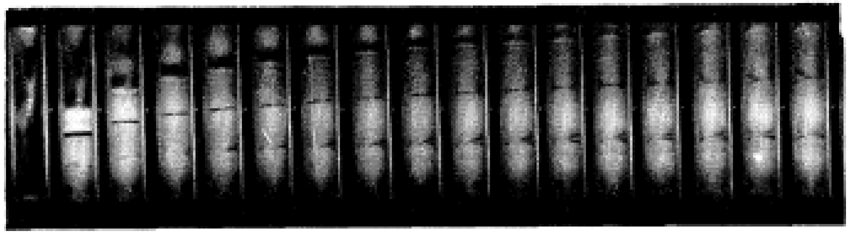
Solitary waves in a nematic LC generated by electroconvection.

A Joets, et al., *Phys. Rev. Lett.*, 1988, **60**, 2164.



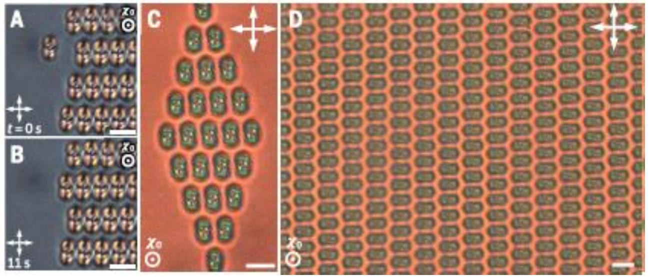
Topological solitons in a cholesteric LC generated by laser tweezer.

II Smalyukh, et al., *Nature Materials*, 2010, **9**, 139.



Propagation of solitary waves in a nematic LC generated by a mechanical method.

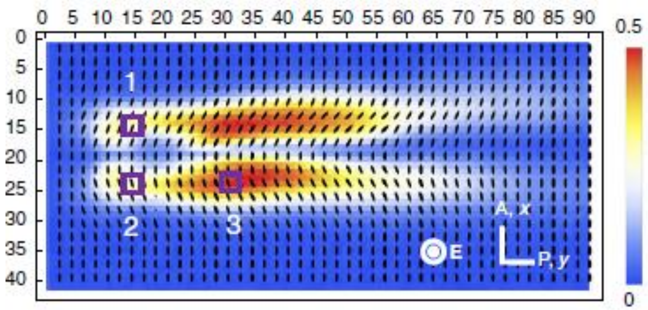
GZ Zhu, et al., *Phys. Rev. Lett.*, 1982, **49**, 1332.



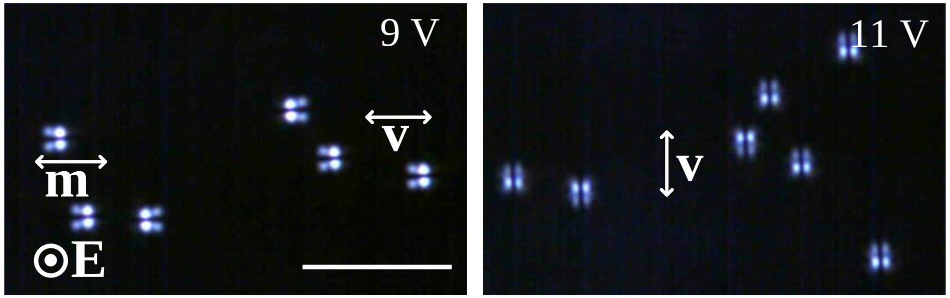
Crystals of 3D solitary knots in cholesteric LCs generated by laser tweezer.

JSB Tai, et al., *Science*, 2019, **365**, 1449-1453.

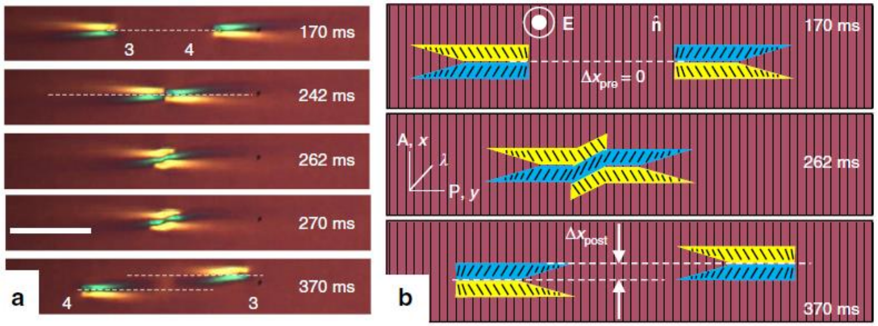
2、Dissipative solitons in nematics with negative dielectric anisotropy



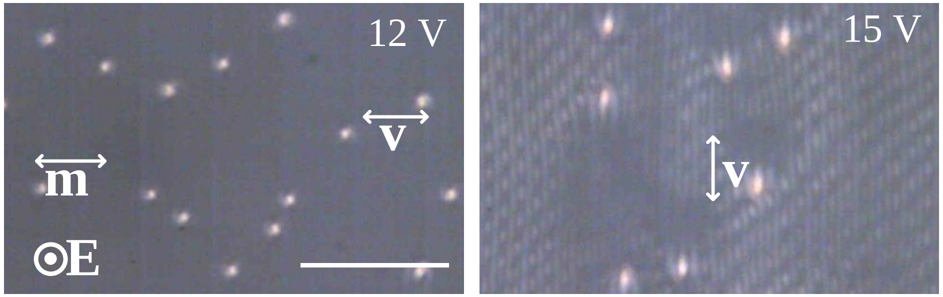
Director structure of a dissipative soliton.



Dissipative solitons in an achiral nematic



Two solitons pass through each other



Dissipative solitons in a chiral nematic

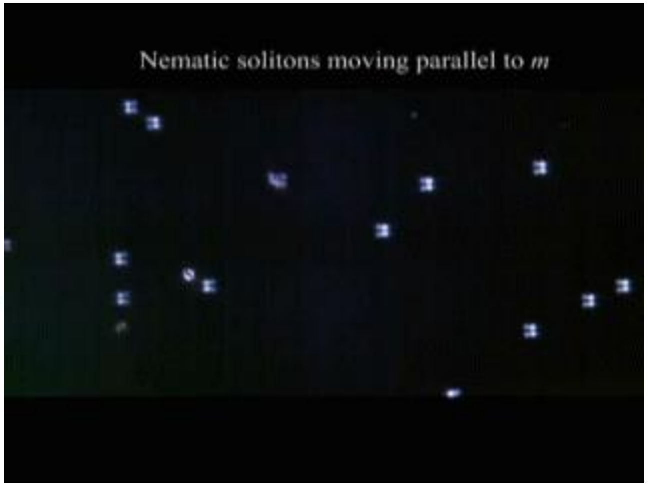
m: alignment direction, **v**: velocity, **E**: electric field

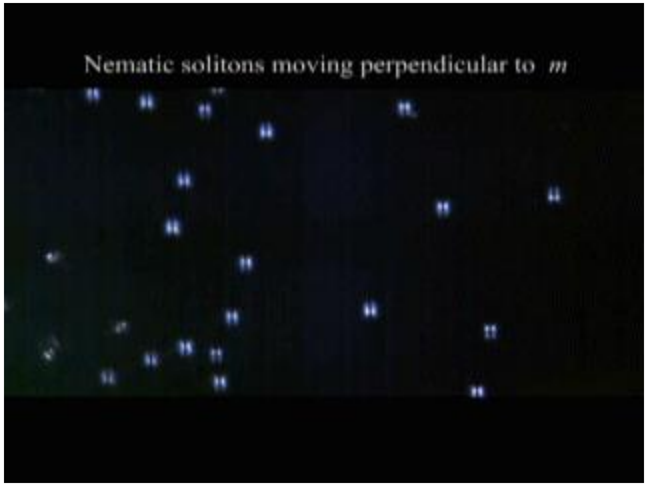
BX Li, et al., *Nature Communications*, 2018, **9**, 2912.

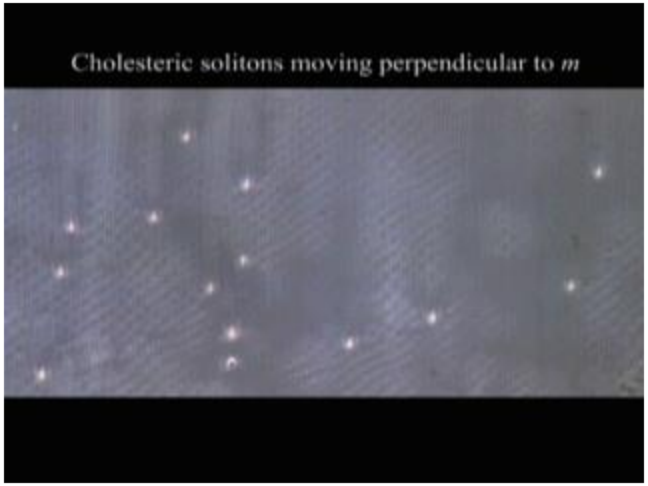
Y Shen & I Dierking, *Communications Physics*, 2020, **3**, 1.

Solitons in an achiral system

Solitons in a chiral system







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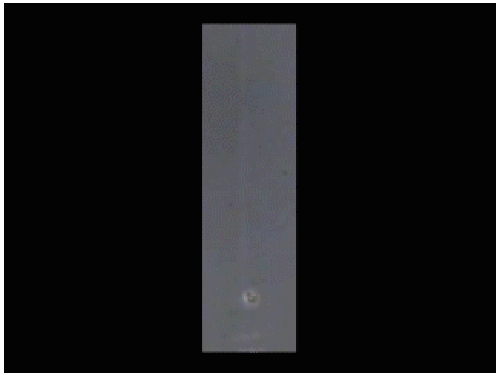
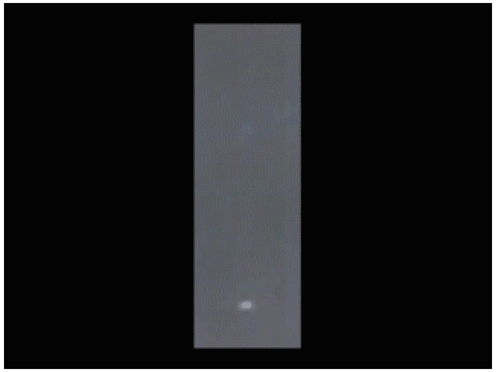
Nucleation of solitons in the chiral system

Nucleation of solitons at electrode edges

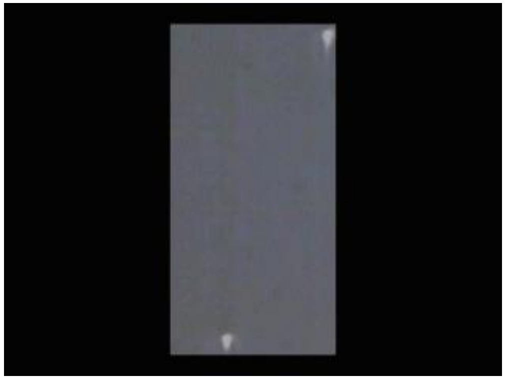
Nucleation of solitons in electro-convection domains



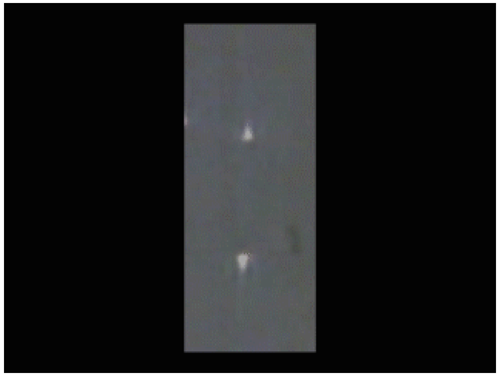
Nucleation of solitons at a dust particle



Nucleation of solitons at a site where no irregularity is observed



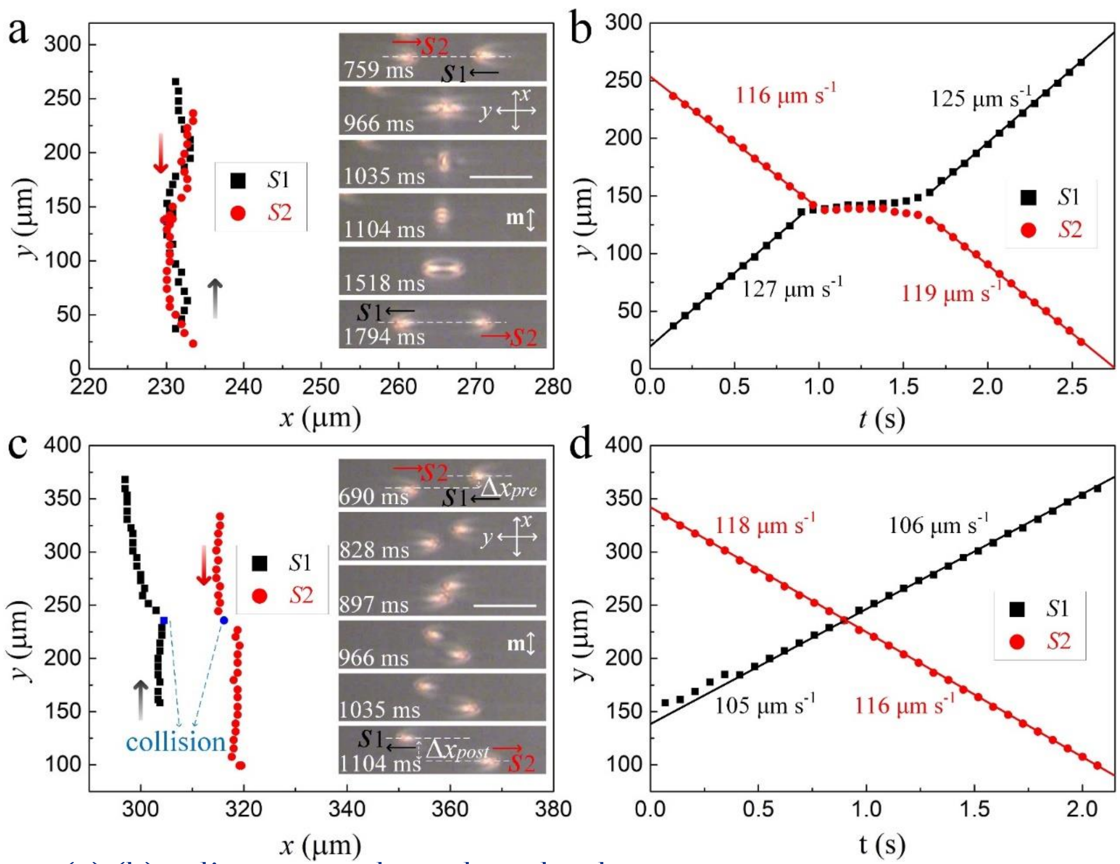
A soliton split into two

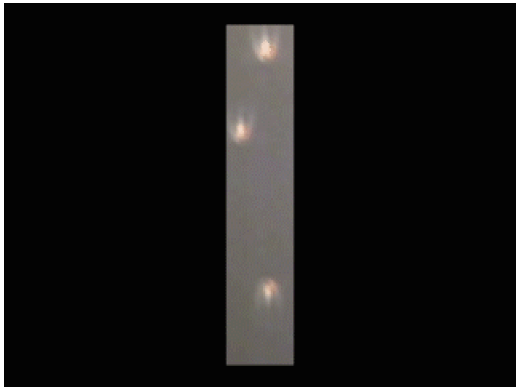


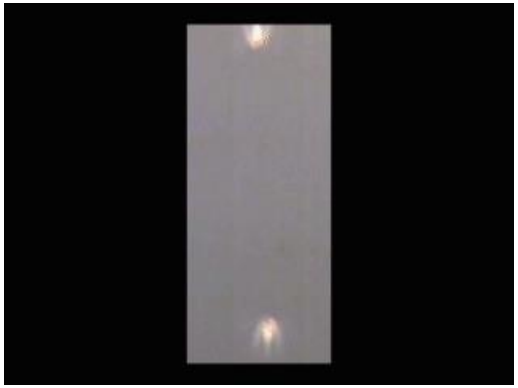
Two solitons collide and generate four solitons

Communications Physics, 2020, **3**, 1.

Interactions of solitons in the chiral system







(a) (b) solitons pass through each other.

(c) (d) solitons collide and reflect into different directions.

m: alignment direction, **v**: velocity

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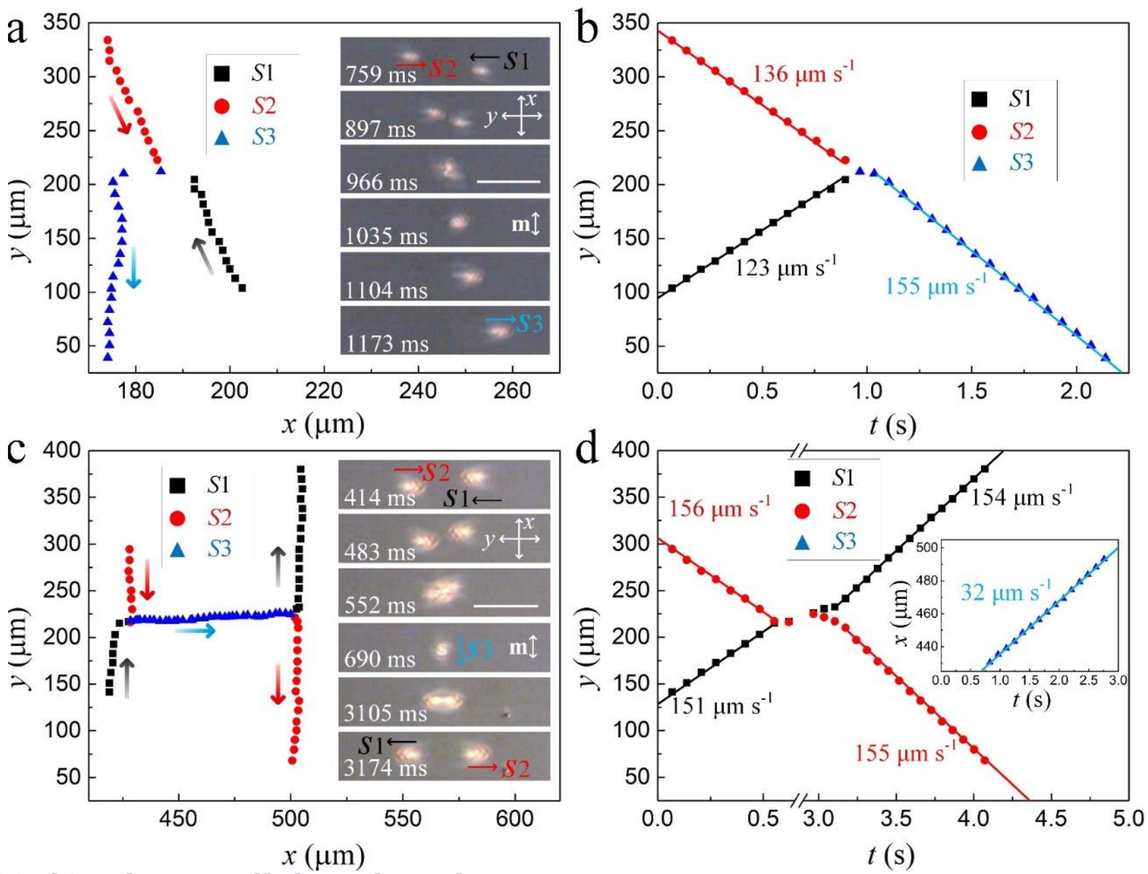

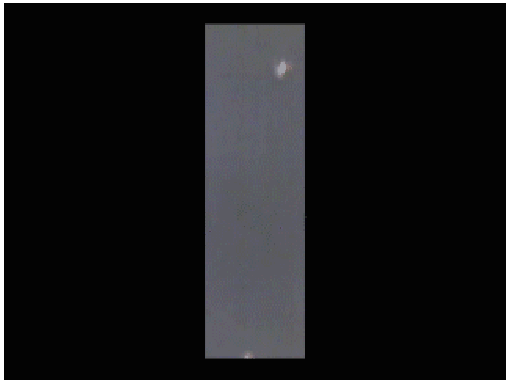

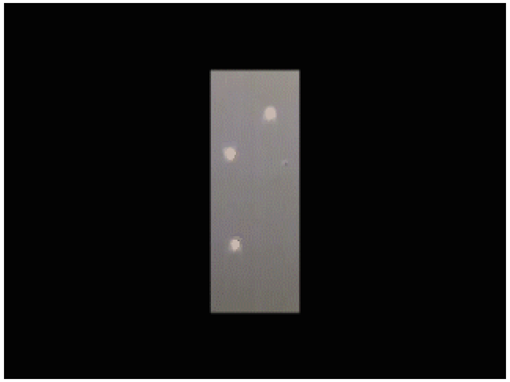

(a) (b) solitons collide and combine into one.

(c) (d) solitons collide and combine into one which move along the y-axis.

m: alignment direction, **v**: velocity

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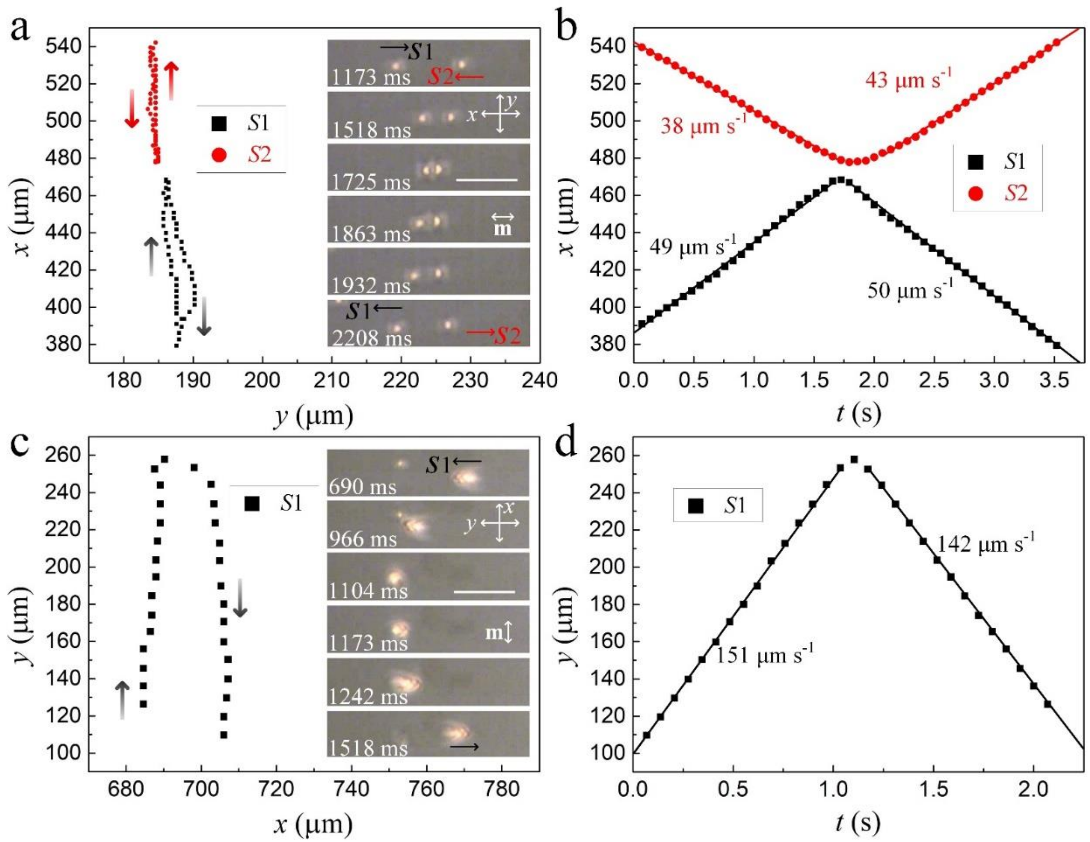

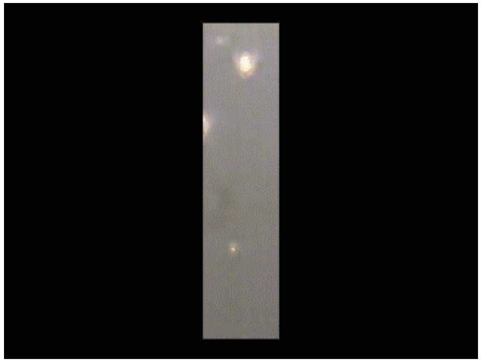

(a) (b) solitons collide and reflect into opposite directions.
(c) (d) Interaction between a soliton and a dust particle.
m: alignment direction, **v**: velocity

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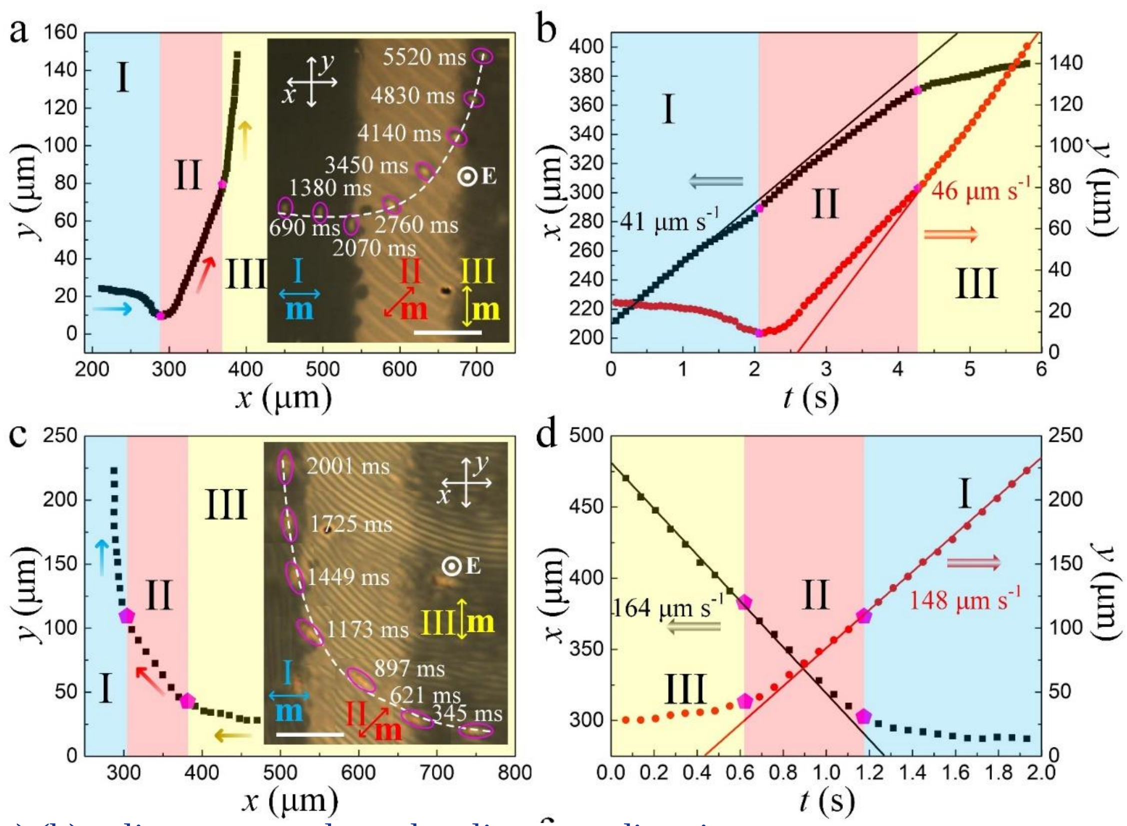
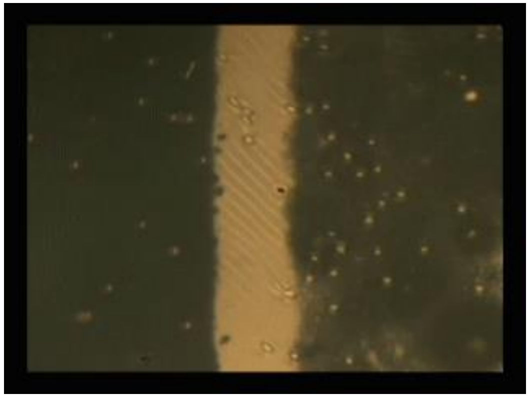
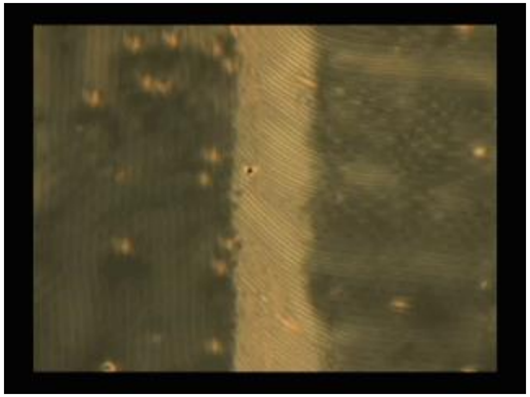
Motion of solitons through multi-domains



(a) (b) solitons move along the alignment direction.
(c) (d) solitons move perpendicular to the alignment direction.
m: alignment direction, **E**: electric field





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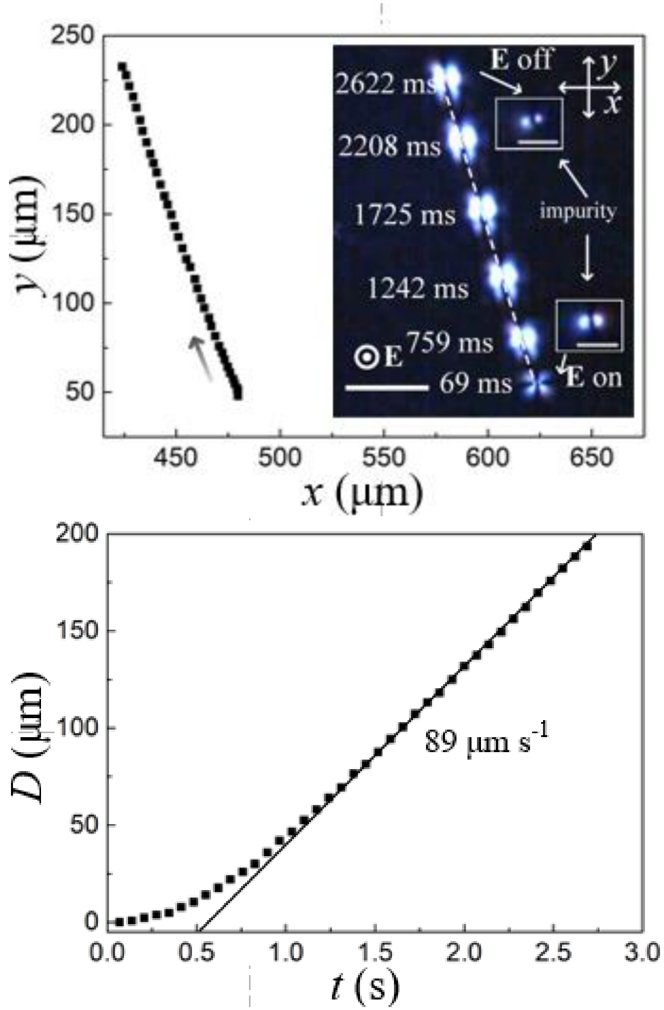
Cargo transport by a soliton



A soliton is induced around a dust particle and carries it move through the nematic bulk.

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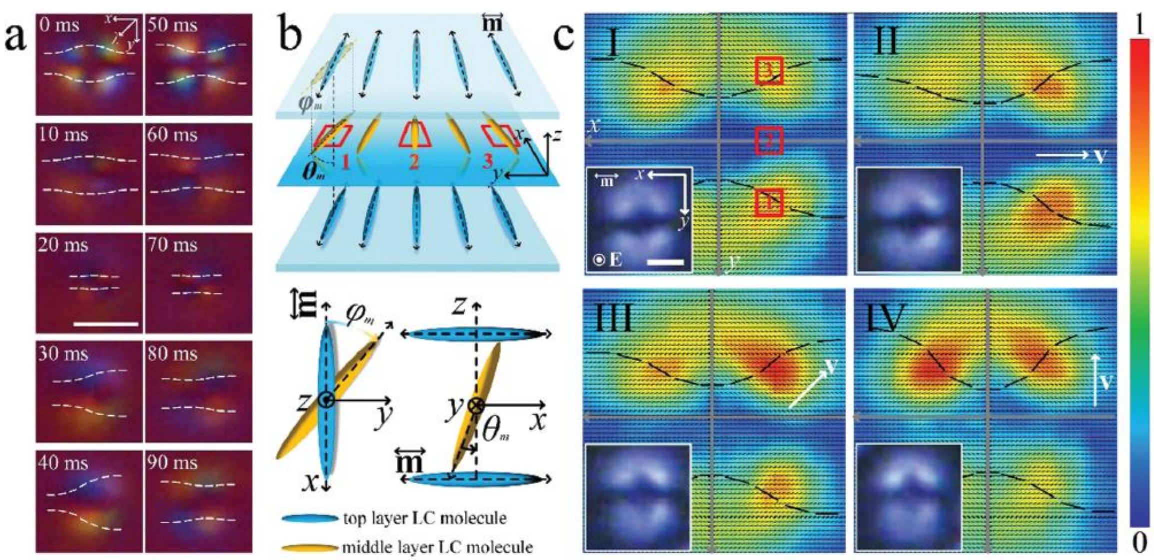
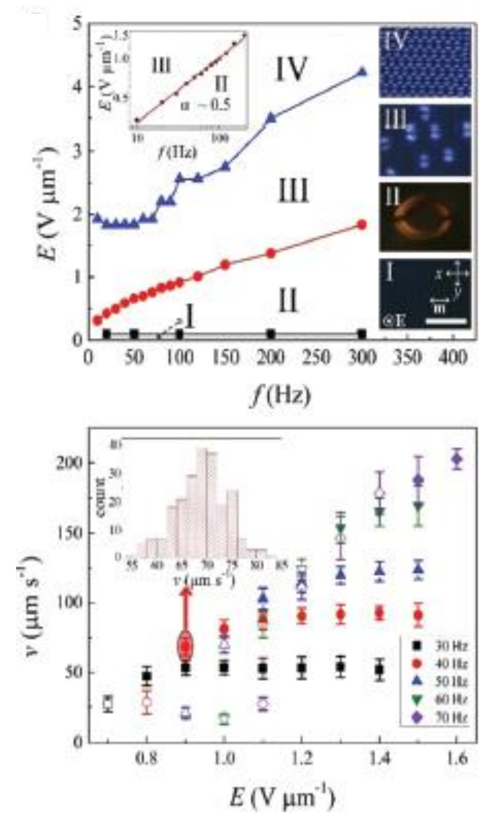
3. Dissipative solitons in nematics with positive dielectric anisotropy



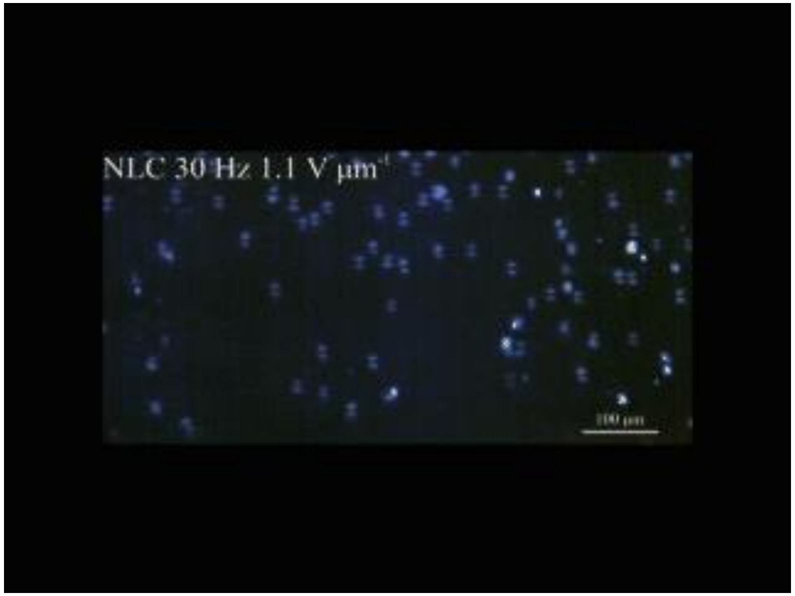
Director structure of a dissipative soliton in LCs with positive dielectric anisotropy

Soft Matter, 2020, **16**, 5325.

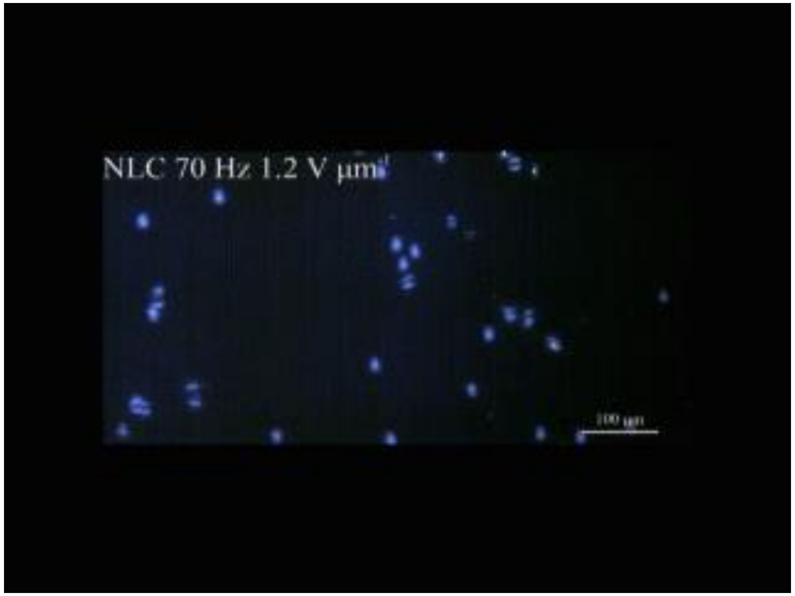


Physical properties of solitons as a function of electric field.

Bidirectional motion of solitons



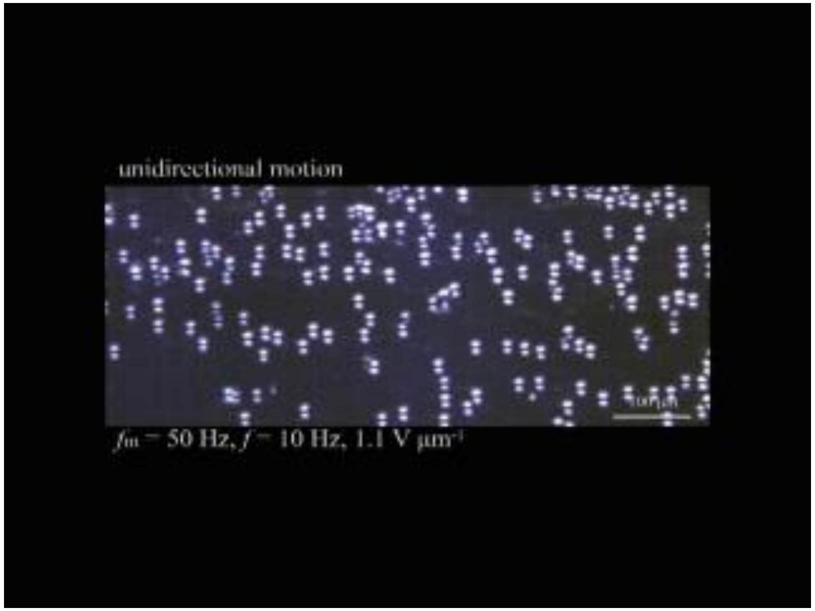
Solitons moving parallel to the alignment direction



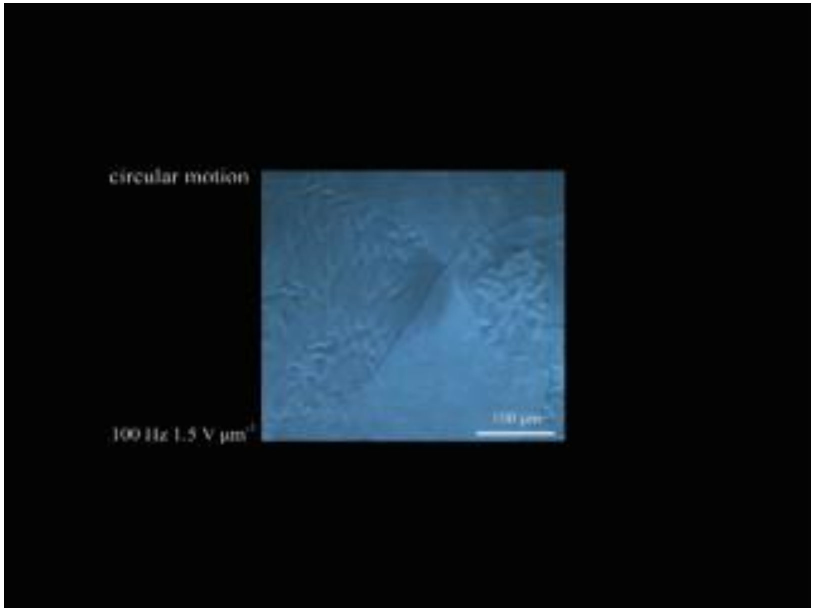
Solitons moving perpendicular to the alignment direction

Soft Matter, 2020, **16**, 5325.

Unidirectional and circular motion of solitons



Unidirectional motion



Circular motion

Soft Matter, 2020, **16**, 5325.

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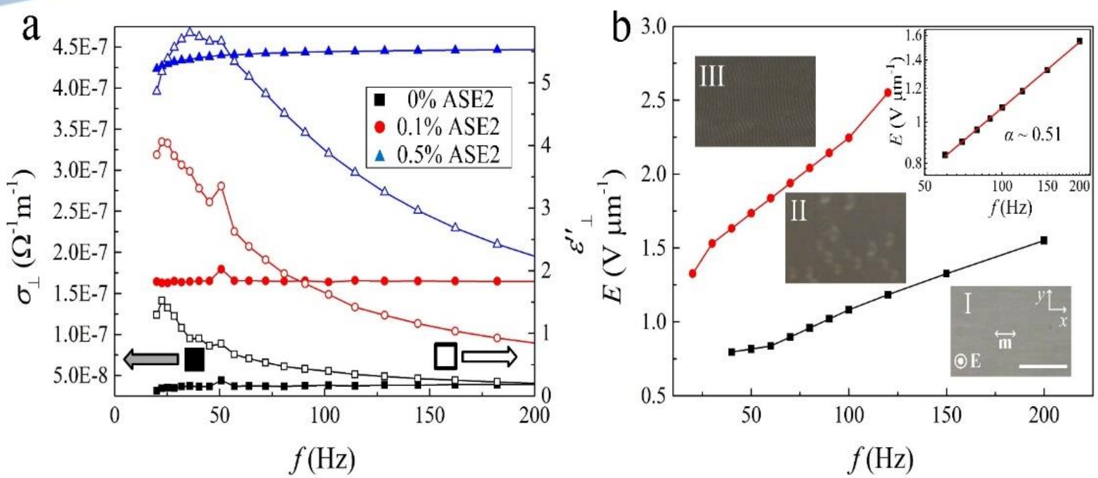
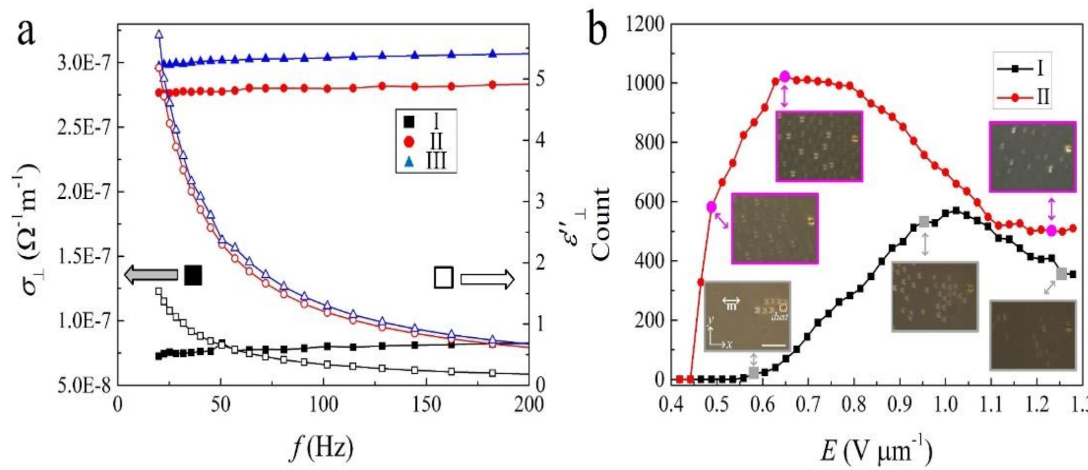


Sample with ***rubbed polymide alignment***

(a) Conductivity and dielectric loss of nematics with different ion concentrations.
(b) Thresholds of different states.

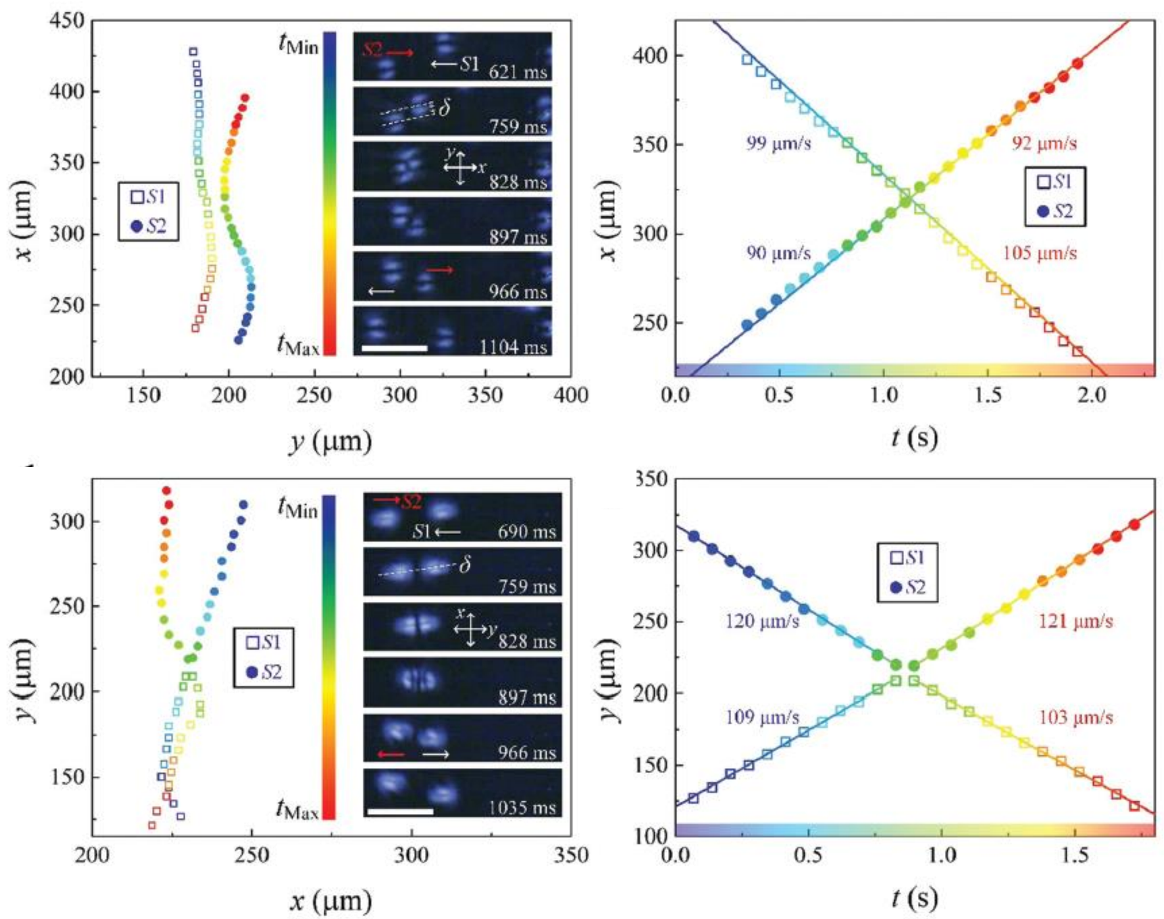


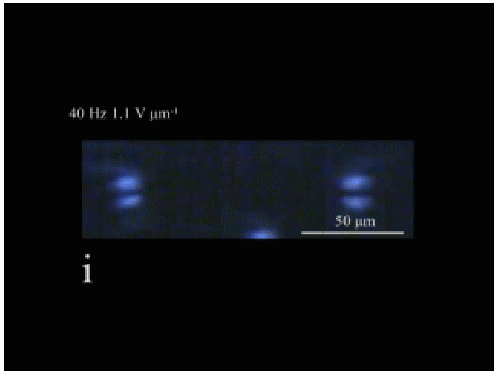
Sample with ***photo-alignment***

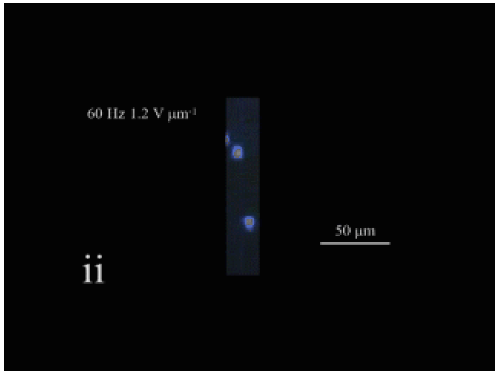
(a) Conductivity and dielectric of nematics of different ion concentrations.
(b) The number of solitons as a function of electric field.

Soft Matter, 2020, **16**, 5325.

Interactions of solitons







Soft Matter, 2020, **16**, 5325.

Summary

- **Dissipative solitons are generated in LCs with negative dielectric anisotropy due to the flexoelectric and electro-convection effects.**

- **Adding chirality to the system changes the structure and dynamics of the solitons.**

- **Dissipative solitons are also generated in LCs with positive dielectric anisotropy, which is attributed to the nonlinear coupling of the director field and the isotropic flow induced by the motion of ions.**

- **The generation of solitons in LCs with positive dielectric anisotropy is closely dependent on the alignment condition and the concentration of ions.**

- **The motion of the solitons can be controlled by patterned alignment and they can be used as vehicles for micro-cargo transport.**

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I acknowledge the helps from my supervisor Ingo Dierking and my friends Adam Draude and Yizhen Shao.

Thanks for your attention!