Dissipative Solitons in Nematic Liquid Crystals

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1. Solitons in Physics


1. Solitons in Liquid Crystals

Solitary waves in a nematic LC generated by electroconvection.

Topological solitons in a cholesteric LC generated by laser tweezer.

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

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

Propagation of solitary waves in a nematic LC generated by a mechanical method.
2、Dissipative solitons in nematics with negative dielectric anisotropy

Director structure of a dissipative soliton.

Two solitons pass through each other


Dissipative solitons in an achiral nematic

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

Solitons in an achiral system

Nematic solitons moving parallel to $m$

Nematic solitons moving perpendicular to $m$

Solitons in a chiral system

Cholesteric solitons moving parallel to $m$

Cholesteric solitons moving perpendicular to $m$
Nucleation of solitons in the chiral system

- Nucleation of solitons at electrode edges
- Nucleation of solitons in electro-convection domains
- Nucleation of solitons at electrode edges
- A soliton split into two

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- Nucleation of solitons at a dust particle
- Two solitons collide and generate four solitons
- Nucleation of solitons at a site where no irregularity is observed
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.
\textbf{m}: alignment direction, \textbf{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


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

Unidirectional and circular motion of solitons

Unidirectional motion

Circular motion

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

(b) Thresholds of different states.

(a) Conductivity and dielectric of nematics of different ion concentrations.

(b) The number of solitons as a function of electric field.

*Sample with rubbed polymide alignment*

*Sample with photo-alignment*

*Soft Matter, 2020, 16, 5325.*
Interactions of solitons

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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