

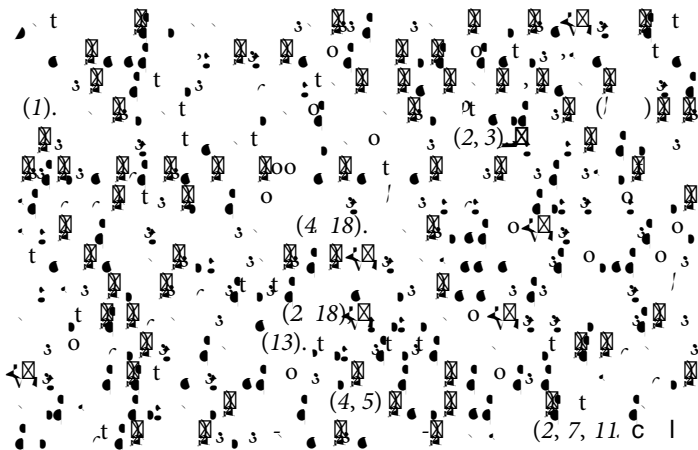
MATERIALS SCIENCE

Transformation between elastic dipoles, quadrupoles, octupoles, and hexadecapoles driven by surfactant self-assembly in nematic emulsion

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Emulsions comprising isotropic fluid drops within a nematic host are of interest for applications ranging from biodetection to smart windows, which rely on changes of molecular alignment structures around the drops in response to chemical, thermal, electric, and other stimuli. We show that absorption or desorption of trace amounts of common surfactants can drive continuous transformations of elastic multipoles induced by the droplets within the uniformly aligned nematic host. Out-of-equilibrium dynamics of director structures emerge from a controlled self-assembly or desorption of different surfactants at the drop-nematic interfaces, with ensuing forward and reverse transformations between elastic dipoles, quadrupoles, octupoles, and hexadecapoles. We characterize inter-transformations of droplet-induced surface and bulk defects, probe elastic pair interactions, and discuss emergent prospects for fundamental science and applications of the reconfigurable nematic emulsions.

INTRODUCTION



(2, 7, 11. c | e 3 7 9 9 T w - t s (-) T j - 0 . 0

$\rho(\mathbf{r}) = \sum_{i=1}^N \delta(\mathbf{r} - \mathbf{r}_i)$ (7, 13, 21, 34).

Elastic adhesion in a thin film anchoring

The elastic adhesion in a thin film anchoring is studied in this section. The total energy functional is given by

$$E[\mathbf{u}, \phi] = \int_{\Omega} \left[\frac{1}{2} \mathbf{u}^T \mathbf{C} \mathbf{u} + \frac{1}{2} \epsilon \nabla \phi \cdot \nabla \phi - \phi \rho(\mathbf{r}) \right] d\mathbf{r} \quad (17)$$

where \mathbf{u} is the displacement vector, \mathbf{C} is the elasticity tensor, ϵ is the surface energy coefficient, and ϕ is the phase field variable. The boundary conditions are given by

$$\mathbf{u} = \mathbf{0} \quad \text{on } \Gamma_D, \quad \mathbf{n} \cdot \mathbf{C} \mathbf{u} = \mathbf{0} \quad \text{on } \Gamma_N, \quad \phi = 1 \quad \text{on } \Gamma_A, \quad \phi = 0 \quad \text{on } \Gamma_B, \quad (18)$$

where Γ_D and Γ_N are the Dirichlet and Neumann boundaries, respectively, and Γ_A and Γ_B are the adhesive and non-adhesive boundaries, respectively. The equilibrium equations are obtained by minimizing the energy functional with respect to \mathbf{u} and ϕ .

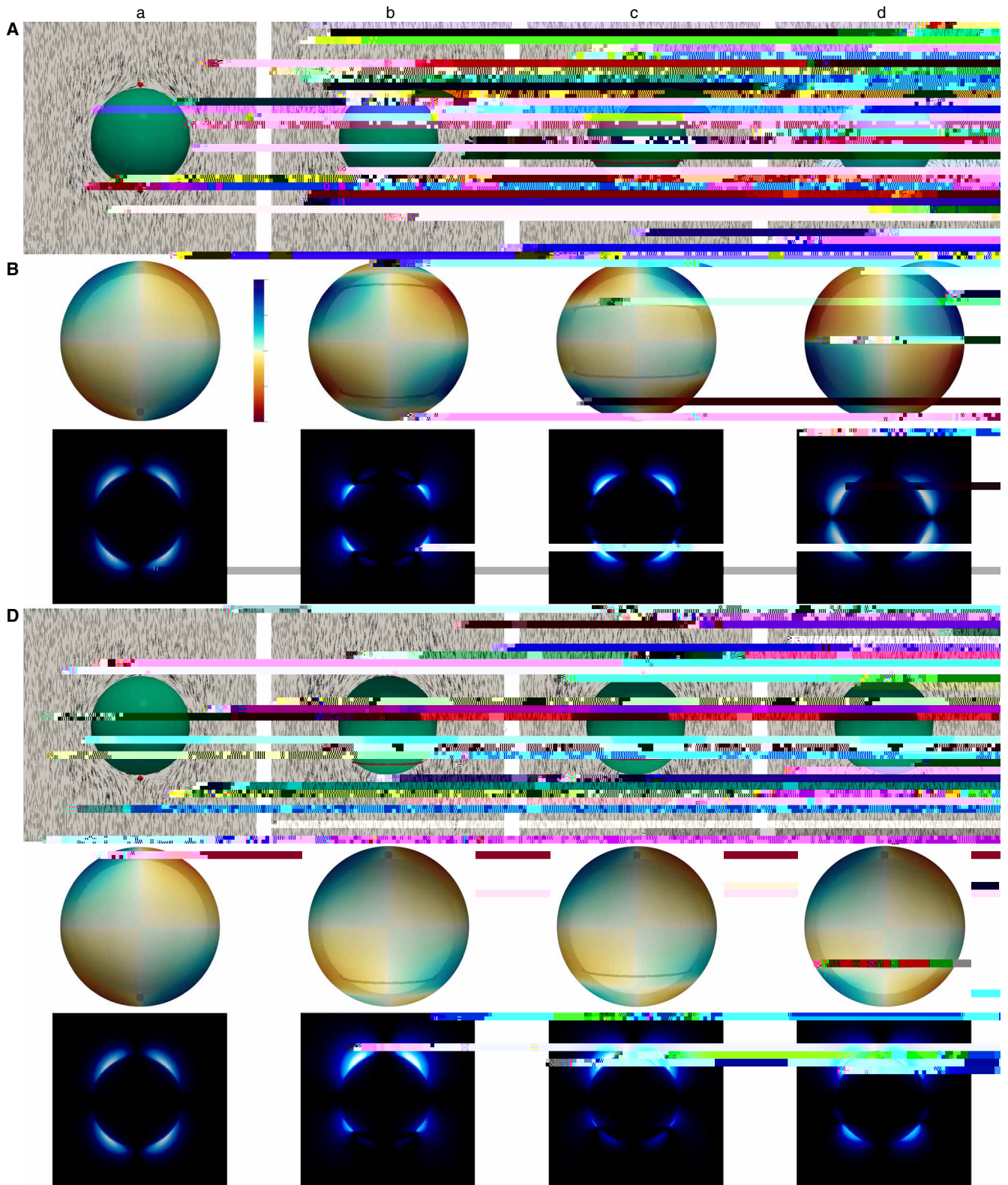
The equilibrium equations are given by

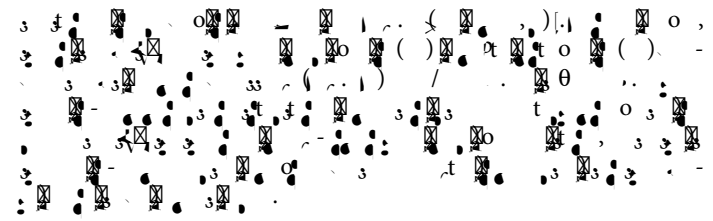
$$\nabla \cdot \mathbf{C} \mathbf{u} = \mathbf{0} \quad \text{in } \Omega, \quad \epsilon \nabla^2 \phi - \rho(\mathbf{r}) = 0 \quad \text{in } \Omega, \quad (19)$$

where \mathbf{n} is the outward normal vector. The equilibrium equations (19) are solved numerically using the finite element method.

The numerical results show that the elastic adhesion in a thin film anchoring is significantly affected by the surface energy coefficient ϵ and the phase field variable ϕ . The results are shown in Figure 17, 19, and 31.

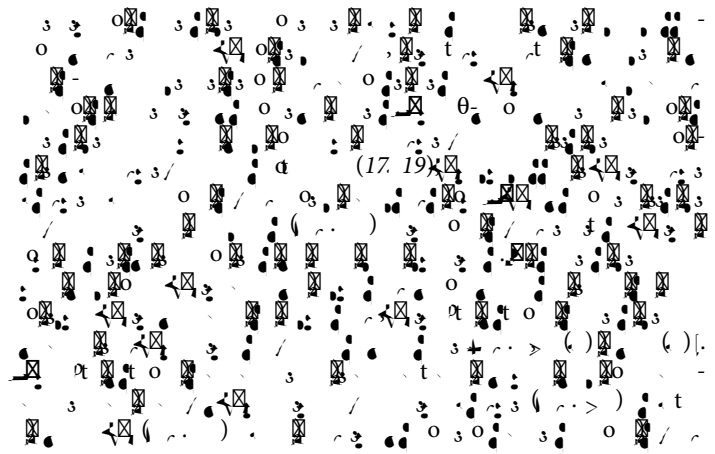
The numerical results show that the elastic adhesion in a thin film anchoring is significantly affected by the surface energy coefficient ϵ and the phase field variable ϕ . The results are shown in Figure 7, 25, and 30.

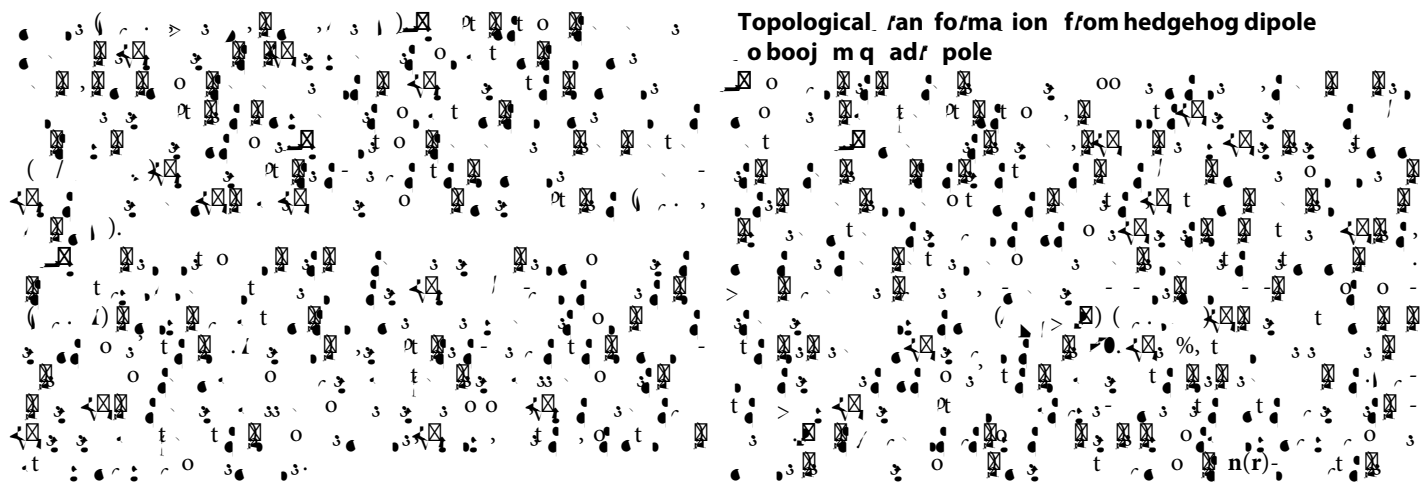
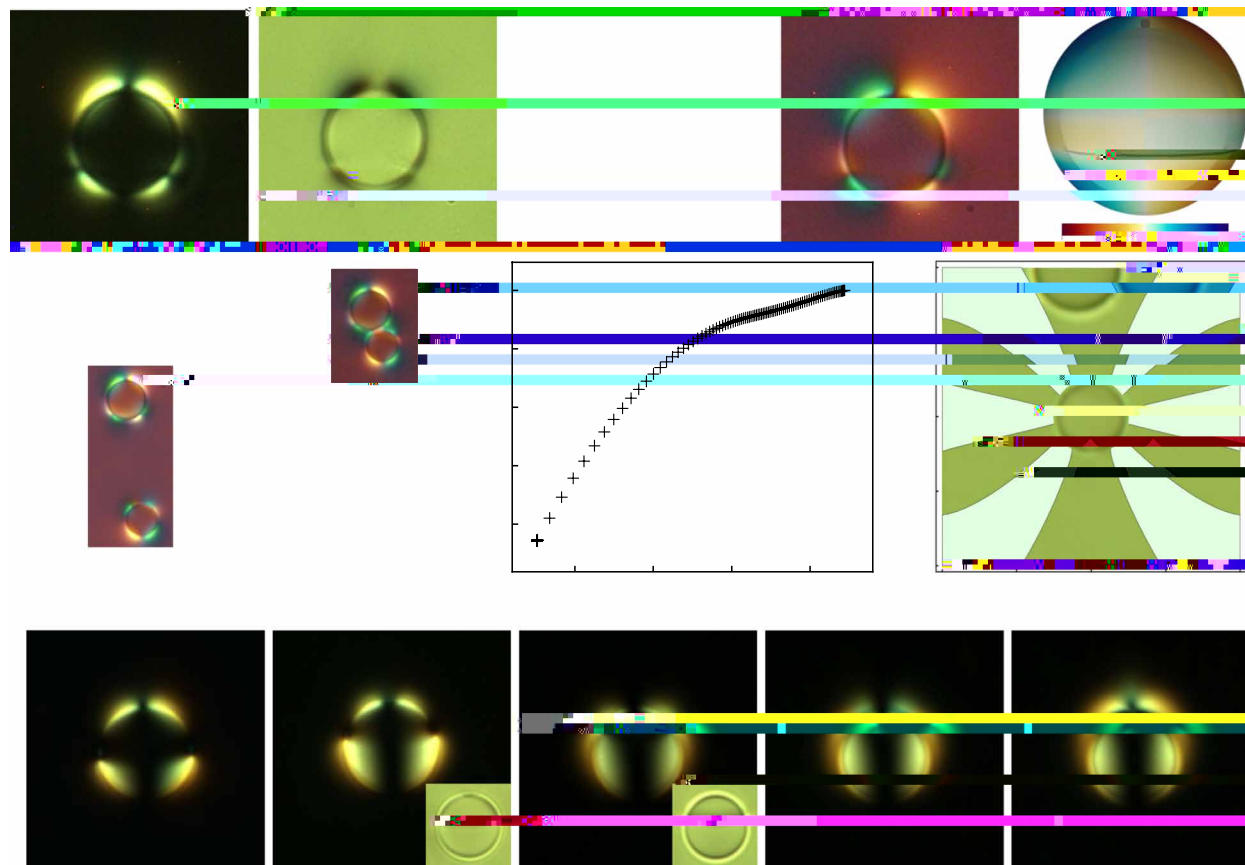


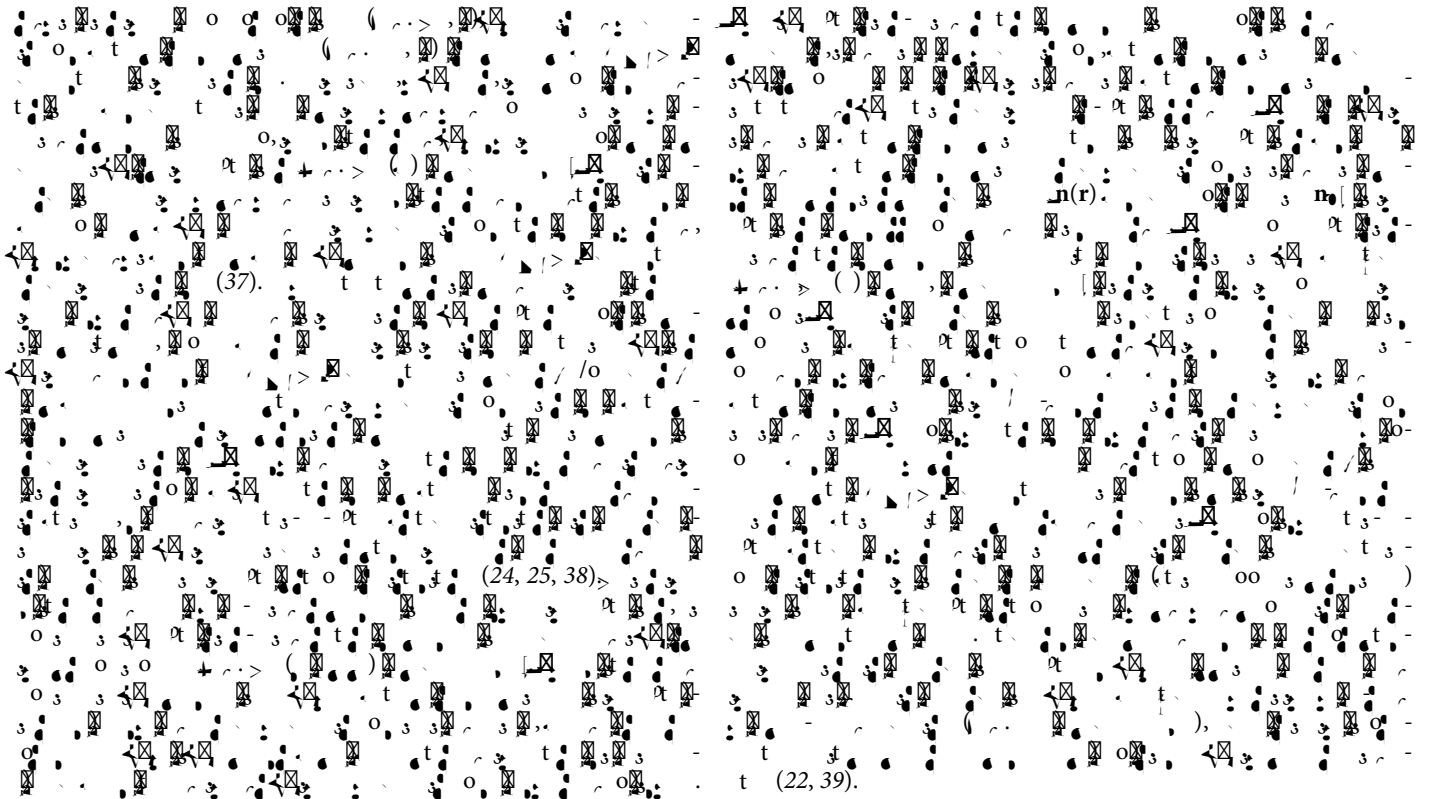
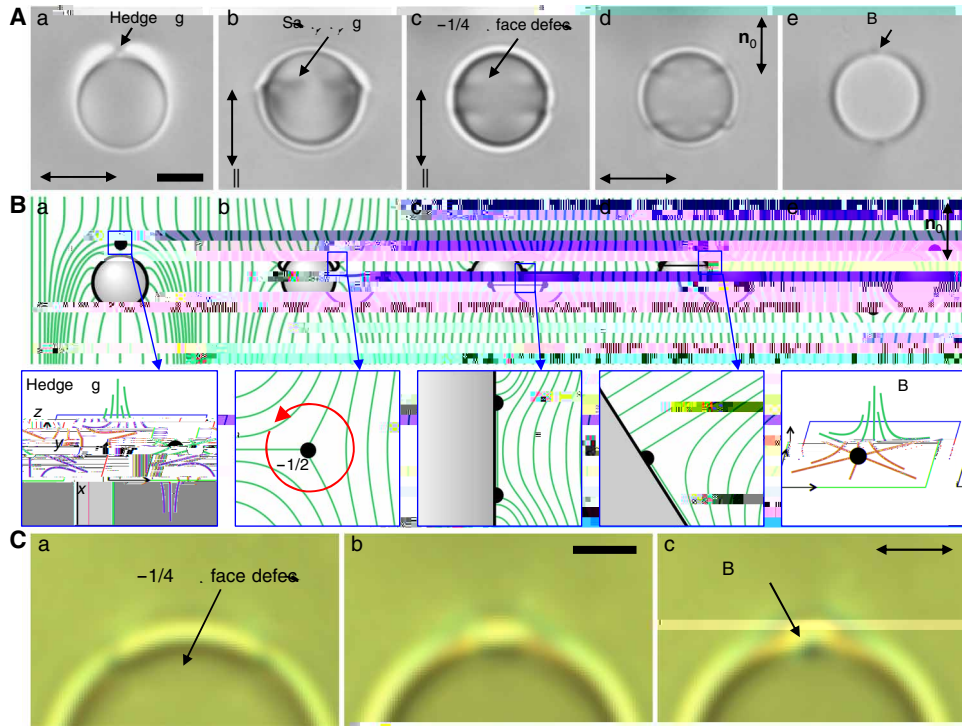


Elastic pole in helical anchoring

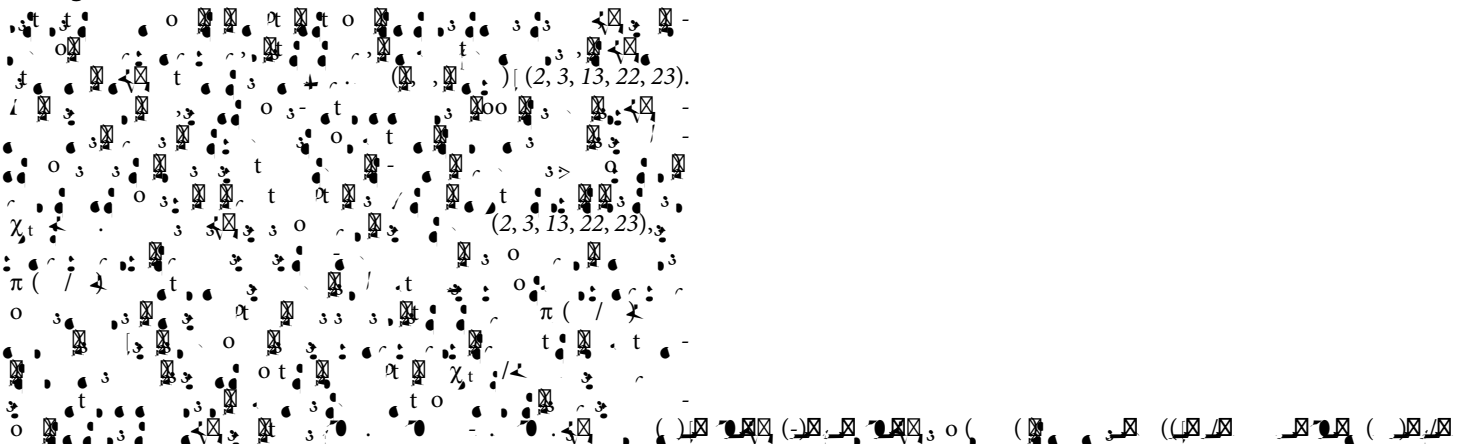
$$\nabla \cdot \mathbf{S} = \mathbf{f} - \mathbf{n}(\mathbf{r}) \cdot \mathbf{t} \quad (17)$$







Fusion, splitting, and other random formation of singular defects



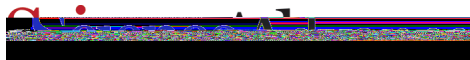
$$L \otimes A_0 \left(\begin{matrix} \cdot \\ \cdot \\ \cdot \end{matrix} \right) \otimes A_0 \left(\begin{matrix} \cdot \\ \cdot \\ \cdot \end{matrix} \right) + A_0 \left(\begin{matrix} \cdot \\ \cdot \\ \cdot \end{matrix} \right) + L \left(\begin{matrix} \cdot \\ \cdot \\ \cdot \end{matrix} \right) \quad (7)$$

$$L \otimes A_0 \left(\begin{matrix} \cdot \\ \cdot \\ \cdot \end{matrix} \right) \otimes A_0 \left(\begin{matrix} \cdot \\ \cdot \\ \cdot \end{matrix} \right) + A_0 \left(\begin{matrix} \cdot \\ \cdot \\ \cdot \end{matrix} \right) + L \left(\begin{matrix} \cdot \\ \cdot \\ \cdot \end{matrix} \right) \quad (8)$$

$$L \otimes A_0 \left(\begin{matrix} \cdot \\ \cdot \\ \cdot \end{matrix} \right) \otimes A_0 \left(\begin{matrix} \cdot \\ \cdot \\ \cdot \end{matrix} \right) + A_0 \left(\begin{matrix} \cdot \\ \cdot \\ \cdot \end{matrix} \right) + L \left(\begin{matrix} \cdot \\ \cdot \\ \cdot \end{matrix} \right) \quad (9)$$

$$L \otimes A_0 \left(\begin{matrix} \cdot \\ \cdot \\ \cdot \end{matrix} \right) \otimes A_0 \left(\begin{matrix} \cdot \\ \cdot \\ \cdot \end{matrix} \right) + A_0 \left(\begin{matrix} \cdot \\ \cdot \\ \cdot \end{matrix} \right) + L \left(\begin{matrix} \cdot \\ \cdot \\ \cdot \end{matrix} \right) \quad (10)$$

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