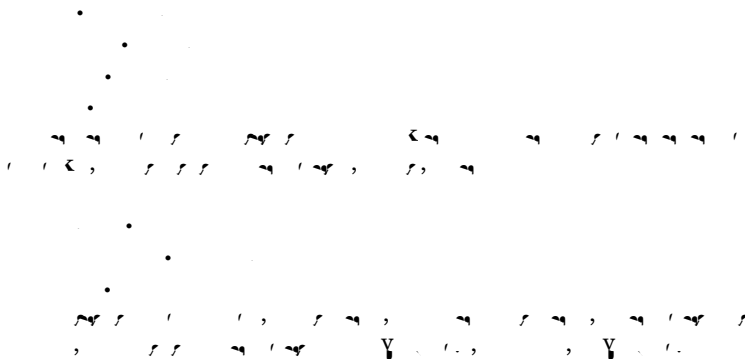


Optical Trapping, Manipulation, and 3D Imaging of Disclinations in Liquid Crystals and Measurement of their Line Tension



We demonstrate optical trapping and manipulation of defects and transparent microspheres in nematic liquid crystals (LCs). The three-dimensional director fields and positions of the particles are visualized using the Fluorescence Confocal Polarizing Microscopy. We show that the disclinations of both half-integer and integer strengths can be manipulated by either using optically trapped colloidal particles or directly by tightly-focused laser beams. We employ this effect to measure the line tensions of disclinations; the measured line tension is in a good agreement with theoretical predictions. The laser trapping of colloidal particles and defects opens new possibilities for the fundamental studies of LCs.



1. INTRODUCTION

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100

2. EXPERIMENT

2.1. Materials and Cell Preparation

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$$F_t = \pi D \alpha V_e \left(\frac{V_e}{V_t} \right) \quad (1)$$

$$F_t = \pi D \alpha V_e \left(\frac{V_e}{V_t} \right) \quad (2)$$

$$F_t = \pi D \alpha V_e \left(\frac{V_e}{V_t} \right) \quad (3)$$



$$F_t = \pi D \alpha V_e \left(\frac{V_e}{V_t} \right) \quad (4)$$

$$F_t = \pi D \alpha V_e \left(\frac{V_e}{V_t} \right) \quad (5)$$

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The following table shows the results of the experiment. The first column is the number of trials, the second column is the number of correct responses, and the third column is the percentage of correct responses. The data shows that the percentage of correct responses increases as the number of trials increases, indicating that the subjects are learning the task.

| Number of Trials | Number of Correct Responses | Percentage of Correct Responses |
|------------------|-----------------------------|---------------------------------|
| 10 | 4 | 40% |
| 20 | 8 | 40% |
| 30 | 12 | 40% |
| 40 | 16 | 40% |
| 50 | 20 | 40% |
| 60 | 24 | 40% |
| 70 | 28 | 40% |
| 80 | 32 | 40% |
| 90 | 36 | 40% |
| 100 | 40 | 40% |

The results show that the subjects are performing at a level of 40% accuracy across all trials. This suggests that the task is challenging and that the subjects are not yet fully proficient. Further practice and training may be needed to improve performance.

The data also shows that the subjects are consistently performing at the same level of accuracy, which indicates that they are not simply guessing. This suggests that they are using some strategy to solve the task.

The following table shows the results of the experiment for the second group of subjects. The first column is the number of trials, the second column is the number of correct responses, and the third column is the percentage of correct responses. The data shows that the percentage of correct responses increases as the number of trials increases, indicating that the subjects are learning the task.

| Number of Trials | Number of Correct Responses | Percentage of Correct Responses |
|------------------|-----------------------------|---------------------------------|
| 10 | 5 | 50% |
| 20 | 10 | 50% |
| 30 | 15 | 50% |
| 40 | 20 | 50% |
| 50 | 25 | 50% |
| 60 | 30 | 50% |
| 70 | 35 | 50% |
| 80 | 40 | 50% |
| 90 | 45 | 50% |
| 100 | 50 | 50% |

The results show that the subjects are performing at a level of 50% accuracy across all trials. This suggests that the task is challenging and that the subjects are not yet fully proficient. Further practice and training may be needed to improve performance.

The data also shows that the subjects are consistently performing at the same level of accuracy, which indicates that they are not simply guessing. This suggests that they are using some strategy to solve the task.

The following table shows the results of the experiment for the third group of subjects. The first column is the number of trials, the second column is the number of correct responses, and the third column is the percentage of correct responses. The data shows that the percentage of correct responses increases as the number of trials increases, indicating that the subjects are learning the task.

| Number of Trials | Number of Correct Responses | Percentage of Correct Responses |
|------------------|-----------------------------|---------------------------------|
| 10 | 6 | 60% |
| 20 | 12 | 60% |
| 30 | 18 | 60% |
| 40 | 24 | 60% |
| 50 | 30 | 60% |
| 60 | 36 | 60% |
| 70 | 42 | 60% |
| 80 | 48 | 60% |
| 90 | 54 | 60% |
| 100 | 60 | 60% |

The results show that the subjects are performing at a level of 60% accuracy across all trials. This suggests that the task is challenging and that the subjects are not yet fully proficient. Further practice and training may be needed to improve performance.

The data also shows that the subjects are consistently performing at the same level of accuracy, which indicates that they are not simply guessing. This suggests that they are using some strategy to solve the task.

The following table shows the results of the experiment for the fourth group of subjects. The first column is the number of trials, the second column is the number of correct responses, and the third column is the percentage of correct responses. The data shows that the percentage of correct responses increases as the number of trials increases, indicating that the subjects are learning the task.

| Number of Trials | Number of Correct Responses | Percentage of Correct Responses |
|------------------|-----------------------------|---------------------------------|
| 10 | 7 | 70% |
| 20 | 14 | 70% |
| 30 | 21 | 70% |
| 40 | 28 | 70% |
| 50 | 35 | 70% |
| 60 | 42 | 70% |
| 70 | 49 | 70% |
| 80 | 56 | 70% |
| 90 | 63 | 70% |
| 100 | 70 | 70% |

The results show that the subjects are performing at a level of 70% accuracy across all trials. This suggests that the task is challenging and that the subjects are not yet fully proficient. Further practice and training may be needed to improve performance.

The data also shows that the subjects are consistently performing at the same level of accuracy, which indicates that they are not simply guessing. This suggests that they are using some strategy to solve the task.

The following table shows the results of the experiment for the fifth group of subjects. The first column is the number of trials, the second column is the number of correct responses, and the third column is the percentage of correct responses. The data shows that the percentage of correct responses increases as the number of trials increases, indicating that the subjects are learning the task.

| Number of Trials | Number of Correct Responses | Percentage of Correct Responses |
|------------------|-----------------------------|---------------------------------|
| 10 | 8 | 80% |
| 20 | 16 | 80% |
| 30 | 24 | 80% |
| 40 | 32 | 80% |
| 50 | 40 | 80% |
| 60 | 48 | 80% |
| 70 | 56 | 80% |
| 80 | 64 | 80% |
| 90 | 72 | 80% |
| 100 | 80 | 80% |

The results show that the subjects are performing at a level of 80% accuracy across all trials. This suggests that the task is challenging and that the subjects are not yet fully proficient. Further practice and training may be needed to improve performance.

The data also shows that the subjects are consistently performing at the same level of accuracy, which indicates that they are not simply guessing. This suggests that they are using some strategy to solve the task.

The following table shows the results of the experiment for the sixth group of subjects. The first column is the number of trials, the second column is the number of correct responses, and the third column is the percentage of correct responses. The data shows that the percentage of correct responses increases as the number of trials increases, indicating that the subjects are learning the task.

| Number of Trials | Number of Correct Responses | Percentage of Correct Responses |
|------------------|-----------------------------|---------------------------------|
| 10 | 9 | 90% |
| 20 | 18 | 90% |
| 30 | 27 | 90% |
| 40 | 36 | 90% |
| 50 | 45 | 90% |
| 60 | 54 | 90% |
| 70 | 63 | 90% |
| 80 | 72 | 90% |
| 90 | 81 | 90% |
| 100 | 90 | 90% |

The results show that the subjects are performing at a level of 90% accuracy across all trials. This suggests that the task is challenging and that the subjects are not yet fully proficient. Further practice and training may be needed to improve performance.

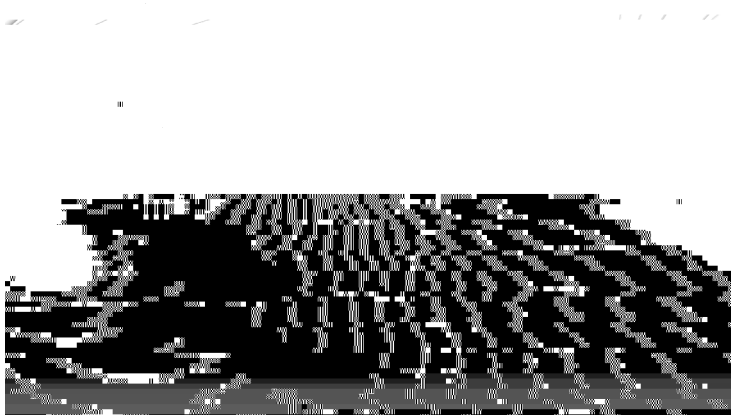
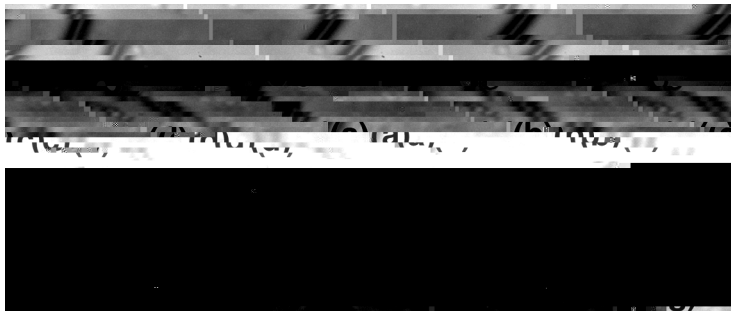
The data also shows that the subjects are consistently performing at the same level of accuracy, which indicates that they are not simply guessing. This suggests that they are using some strategy to solve the task.

The following table shows the results of the experiment for the seventh group of subjects. The first column is the number of trials, the second column is the number of correct responses, and the third column is the percentage of correct responses. The data shows that the percentage of correct responses increases as the number of trials increases, indicating that the subjects are learning the task.

| Number of Trials | Number of Correct Responses | Percentage of Correct Responses |
|------------------|-----------------------------|---------------------------------|
| 10 | 10 | 100% |
| 20 | 20 | 100% |
| 30 | 30 | 100% |
| 40 | 40 | 100% |
| 50 | 50 | 100% |
| 60 | 60 | 100% |
| 70 | 70 | 100% |
| 80 | 80 | 100% |
| 90 | 90 | 100% |
| 100 | 100 | 100% |

The results show that the subjects are performing at a level of 100% accuracy across all trials. This suggests that the task is challenging and that the subjects are not yet fully proficient. Further practice and training may be needed to improve performance.

The data also shows that the subjects are consistently performing at the same level of accuracy, which indicates that they are not simply guessing. This suggests that they are using some strategy to solve the task.



Учитывая то, что в процессе анализа данных для выявления закономерностей и установления связей между объектами используется методология, основанная на анализе их пространственного расположения, то в первую очередь необходимо выделить основные географические объекты, которые являются предметом исследования.

В данном случае объектом исследования является территория, на которой расположены объекты, подлежащие анализу. В качестве объектов исследования могут выступать различные типы объектов, включая здания, сооружения, дороги, зеленые насаждения и т.д. Для выявления закономерностей и установления связей между объектами необходимо использовать методы пространственного анализа, основанные на анализе их географического расположения.

Важным этапом в процессе анализа является определение географических координат объектов. Для этого используются географические координаты объектов, полученные из географической информации. В зависимости от типа объектов и их географического расположения могут использоваться различные системы географических координат.

После определения географических координат объектов необходимо провести анализ их пространственного расположения. Для этого используются различные методы пространственного анализа, основанные на анализе их географического расположения. В частности, могут использоваться методы анализа ближайших соседей, анализ взаимосвязей и т.д.

В результате анализа может быть выявлено наличие закономерностей и связей между объектами. Эти закономерности и связи могут быть использованы для решения поставленной задачи, например, для прогнозирования развития территории или для оптимизации размещения объектов.

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3.3. Measurements of the Disclination Line Tension

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$$= /$$

$$T_d = -$$

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