

Modeliranje širjenja svetlobe vzdolž ograjenih tekočekristalnih defektnih linij

Avtor Miha Čančula

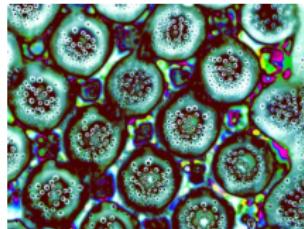
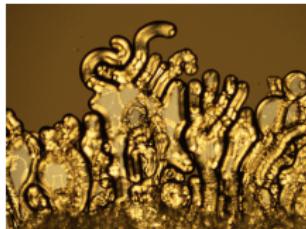
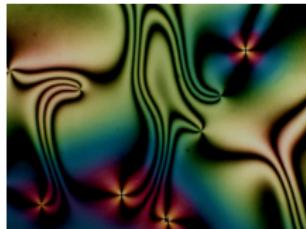
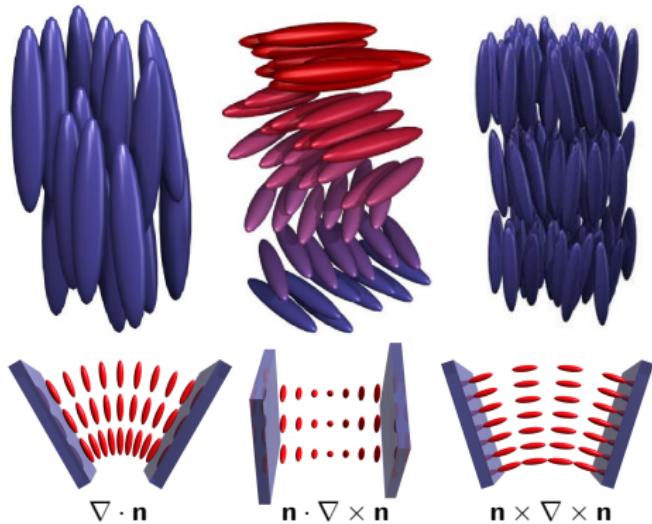
Mentor prof. dr. Slobodan Žumer

Somentor doc. dr. Miha Ravnik

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Tekoči kristali

- Lastnosti tekočin in kristalov
- Orientacijski red
 - Direktor \mathbf{n}
 - Stopnja reda S
 - Simetrija $\mathbf{n} \leftrightarrow -\mathbf{n}$
- Dvolomnost
- Delni pozicijski red
- Nadzor z zunanjimi polji
- Elastične deformacije direktorja



Maxwellove enačbe

$$\nabla \cdot \mathbf{D} = \rho_f$$

$$\nabla \cdot \mathbf{B} = 0$$

$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$$

$$\nabla \times \mathbf{H} = \mathbf{J}_f + \frac{\partial \mathbf{D}}{\partial t}$$

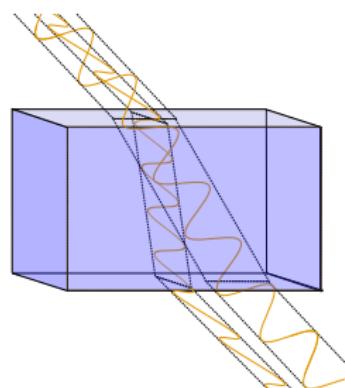
Konstitutivni zvezi

$$\mathbf{D} = \epsilon \epsilon_0 \mathbf{E} \quad \mathbf{B} = \mu \mu_0 \mathbf{H}$$

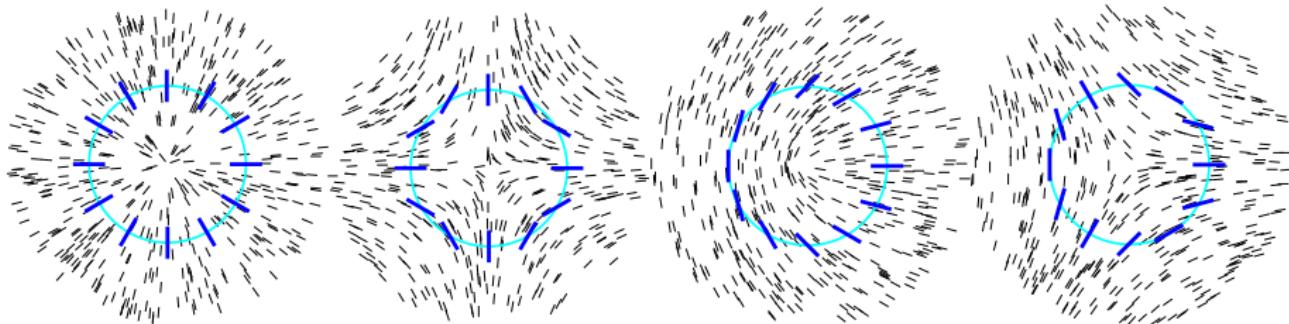
- ϵ in μ sta anizotropna tenzorja
- Ohmov zakon $\mathbf{J} = \sigma \mathbf{E}$
- V vzorcu ni prostih nabojev ($\rho_f = 0$)
- Izredna os vzporedna z direktorjem

Dvolomnost

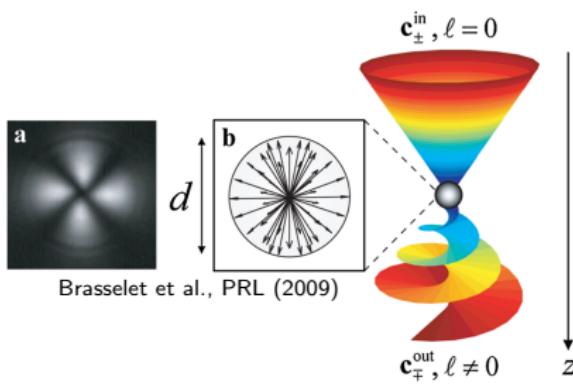
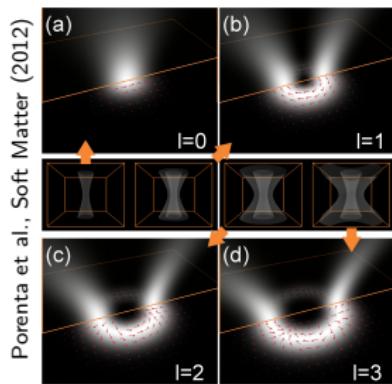
- Lomni količnik odvisen od polarizacije svetlobe
- Ena izredna os z n_e pravokotne smeri n_o



Defekti



- Območje zmanjšanega reda
- Ovojno število – celo za vektorska polja, polcelo za direktor



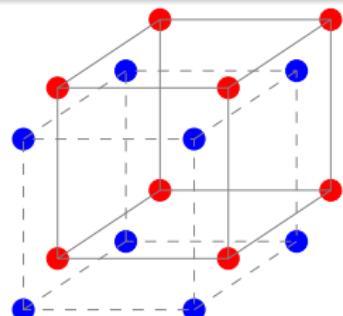
Metoda končnih diferenc v časovni domeni – FDTD

- Časovni razvoj vseh 6 komponent \mathbf{E} in \mathbf{B}
- Dinamični Maxwellovi enačbi na diskretni mreži

$$\frac{\partial \mathbf{B}}{\partial t} = -\nabla \times \mathbf{E} \quad \frac{\partial \mathbf{E}}{\partial t} = \varepsilon^{-1}(\nabla \times \mathbf{B} - \sigma \mathbf{E})$$

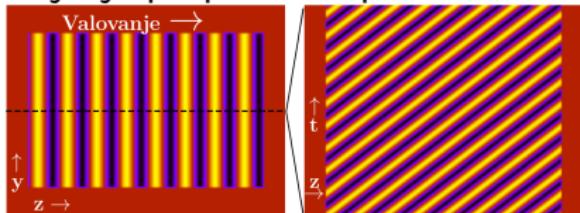
Diskretizacija na mreži

- Komponente polj znane na različnih krajih ob različnih časih
- Izvor in absorpcija valovanja na robu

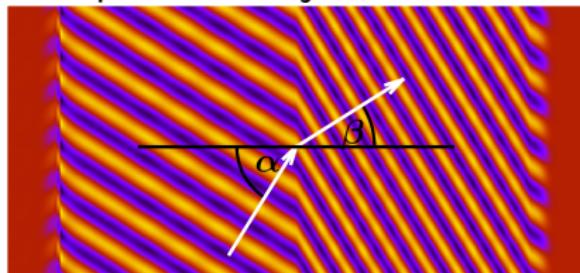


Primeri uporabe metode

- Širjenje po praznem prostoru

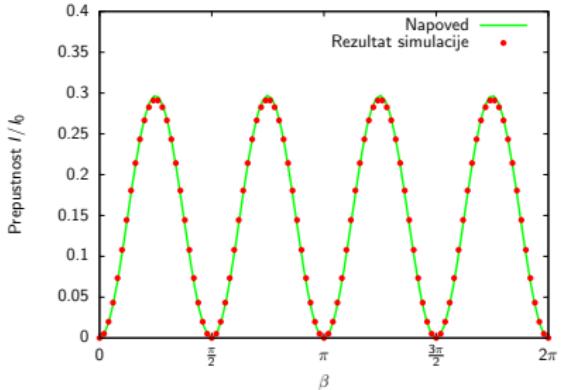


- Lom pri Brewsterjevem kotu

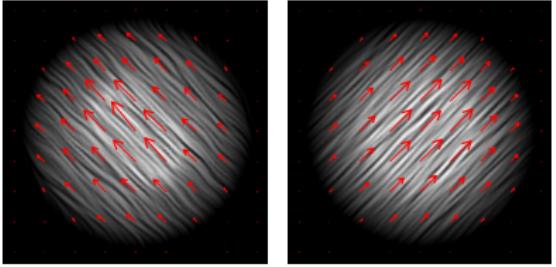


- Fotonski kristal

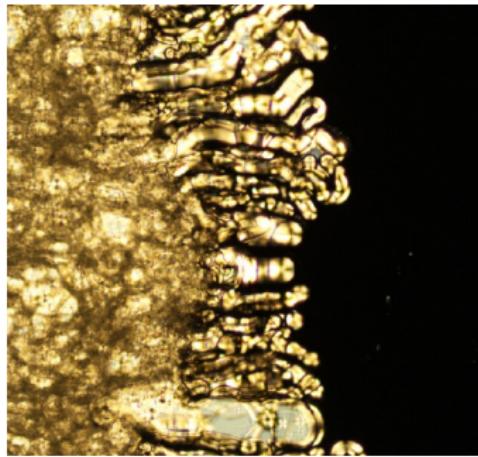
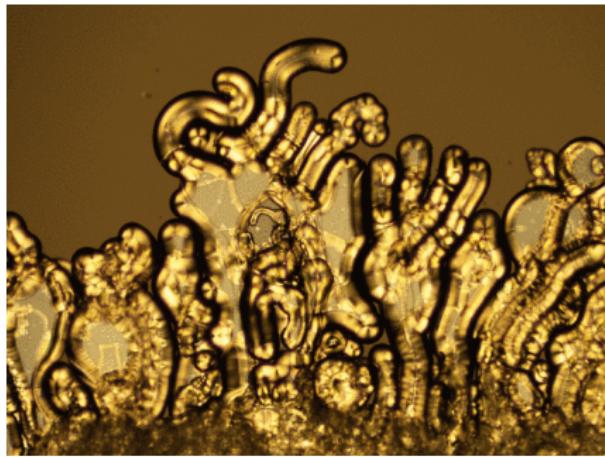
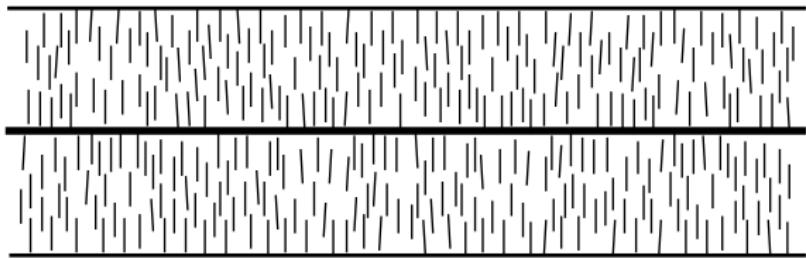
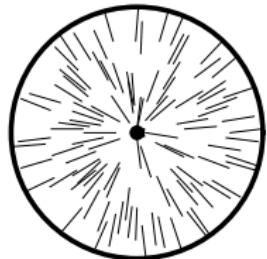
- Uniformen dvolomni kristal



- Dvolomno vlakno

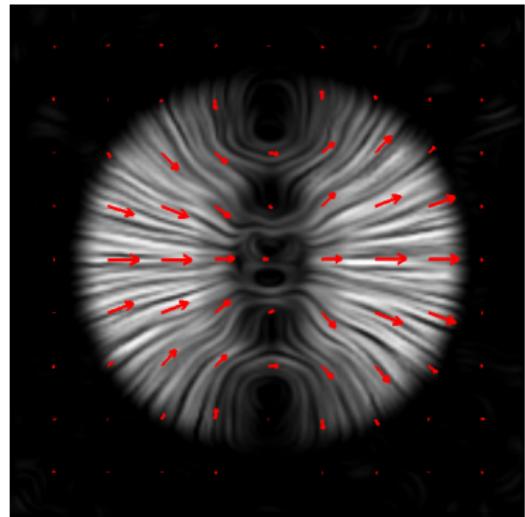
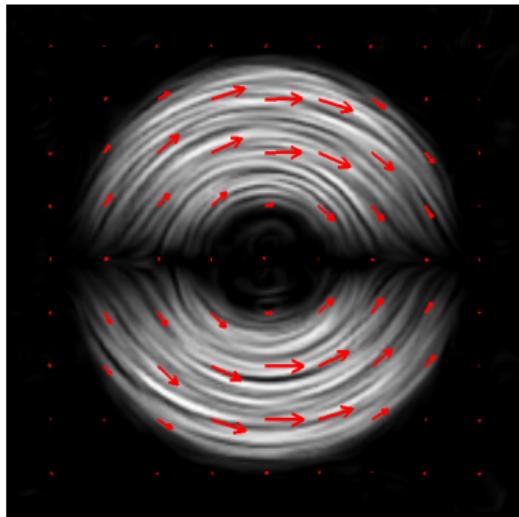


Vlakno z radialnim direktorskim profilom



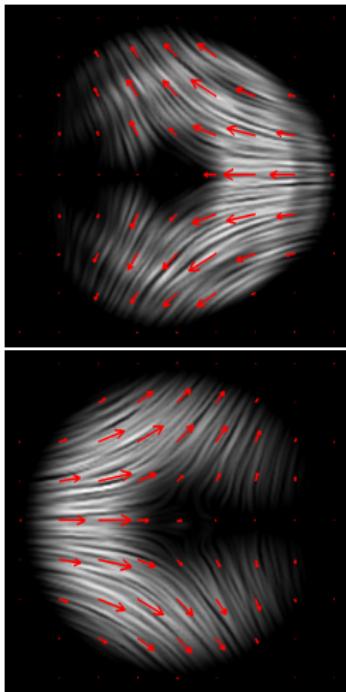
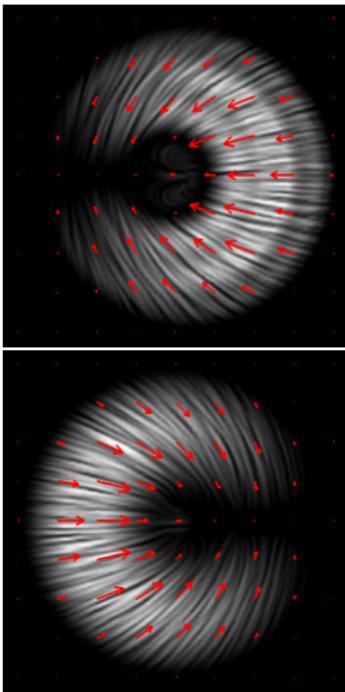
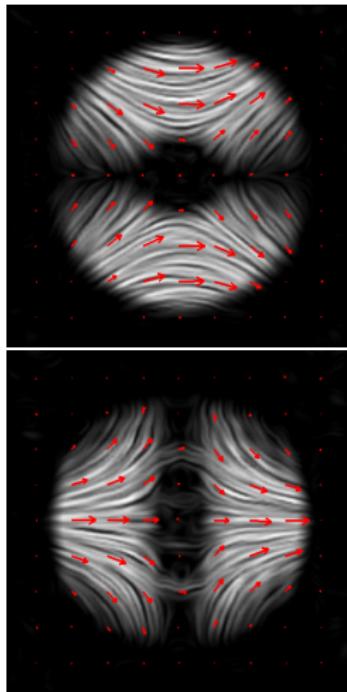
Peddireddy et al., Langmuir (2012)

Sunek v vlaknu z radialnim direktorskim profilom

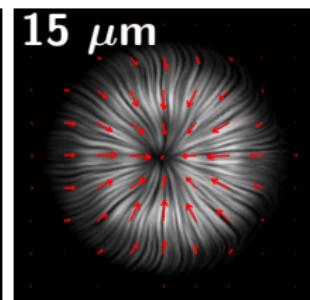
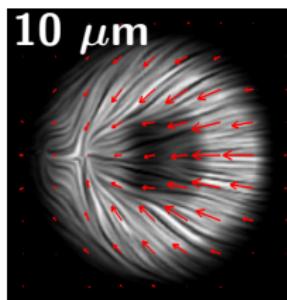
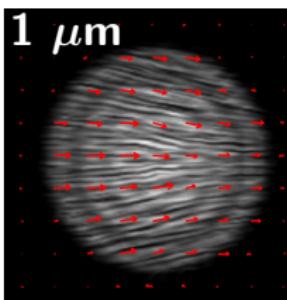
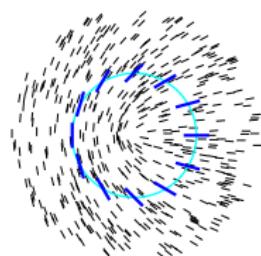
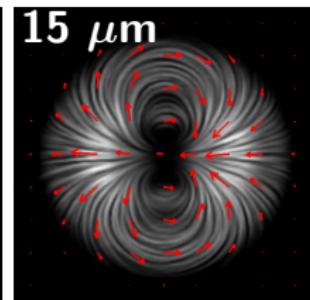
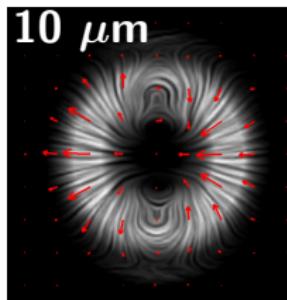
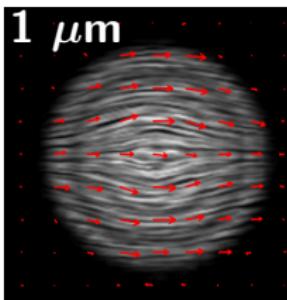
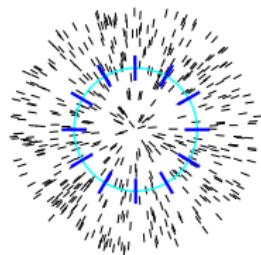


- Sunek razpade na dva stacionarna načina – redni in izredni
- Temna območja zaradi vpadne polarizacije
- “Neprava” defekta z ovojnim številom +1

Sunek v vlaknih z različnimi defekti

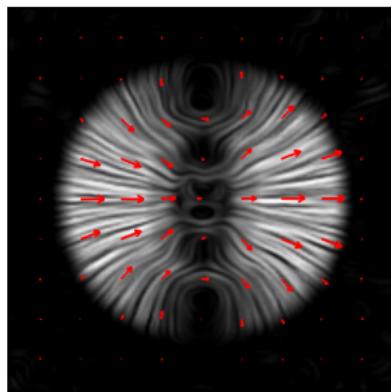


Stalna laserska svetloba

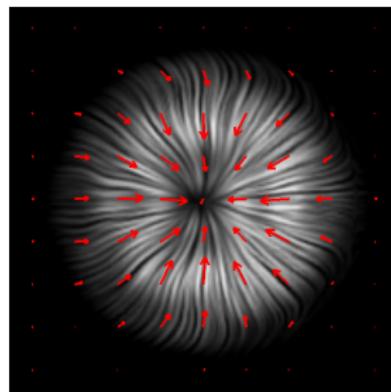


Stalna laserska svetloba

- Kombinacija dveh stacionarnih načinov, različni hitrosti
- Stacionarno stanje, polje na vsakem mestu niha
- Pretvorba v radialno polarizirano svetlobo
- Brez temnih ravnin – obrat polarizacije za 90°



sunek

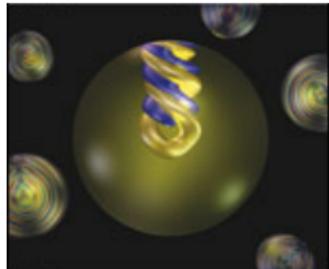


stalna svetloba

Nadaljnje raziskave

Numerična metoda

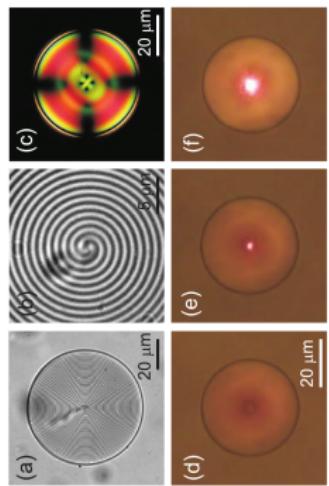
- Sklopitev med svetlobo in tekočim kristalom
- Tekočekristalne kapljice in vlakna kot laserji
- Metamateriali – zapletene strukture
- Natančne transmisijske slike
- Povezava med teorijo in eksperimenti



Seč et al., Soft Matter (2012)

Tekočekristalna vlakna

- Pretvorba polarizacije svetlobe
- Optične komunikacije
- Laserska svetloba v vse smeri



Humar, Muševići, Optics Express (2010)