Modeling of light propagation through smectic waveguides

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Motivation

- Light guiding structure play an important role in modern communication systems

- Unique optical properties of liquid crystals make them extremely useful for guiding light

- Smectic fibres with radial director can be created in a laboratory using 8CB and a surfactant[**?**]

- Point defect in a nematic droplet turns a Gaussian beam into Laguerre-Gaussian – is there a similar effect caused by the line defect in a fibre?

Methods

- FDTD method – direct time evolution of electromagnetic fields in 3D with fully anisotropic ε

- Simulate "infinite" cylindrical waveguide with periodic boundary conditions in z direction

- Observe propagation of Gaussian laser pulse

- Staggered grid, adapted for dielectric anisotropy
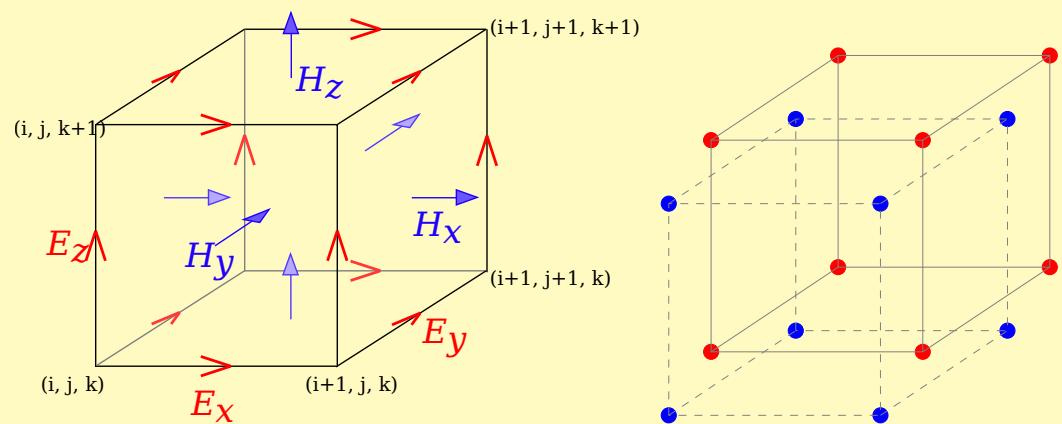
Left: Yee lattice, optimized for diagonal dielectric tensor.
Right: The lattice we used, suitable for full anisotropic ε.
In both cases $\vec{E}$ and $\vec{H}$ are known at different times

- Cylindrical waveguide with a radial director profile and a singular disclination line along its axis
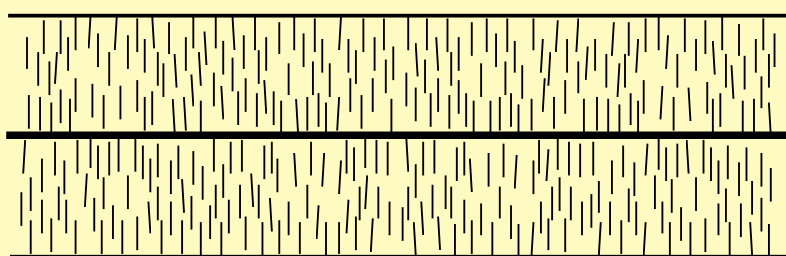
In experiments, melting into the isotropic phase occurs around the disclination line. The size of this melting is much smaller than the wavelength and was therefore neglected.

References

Electric field

We showed that a Gaussian beam entering a fibre quickly turns into a Laguerre-Gaussian beam, and then into something else.
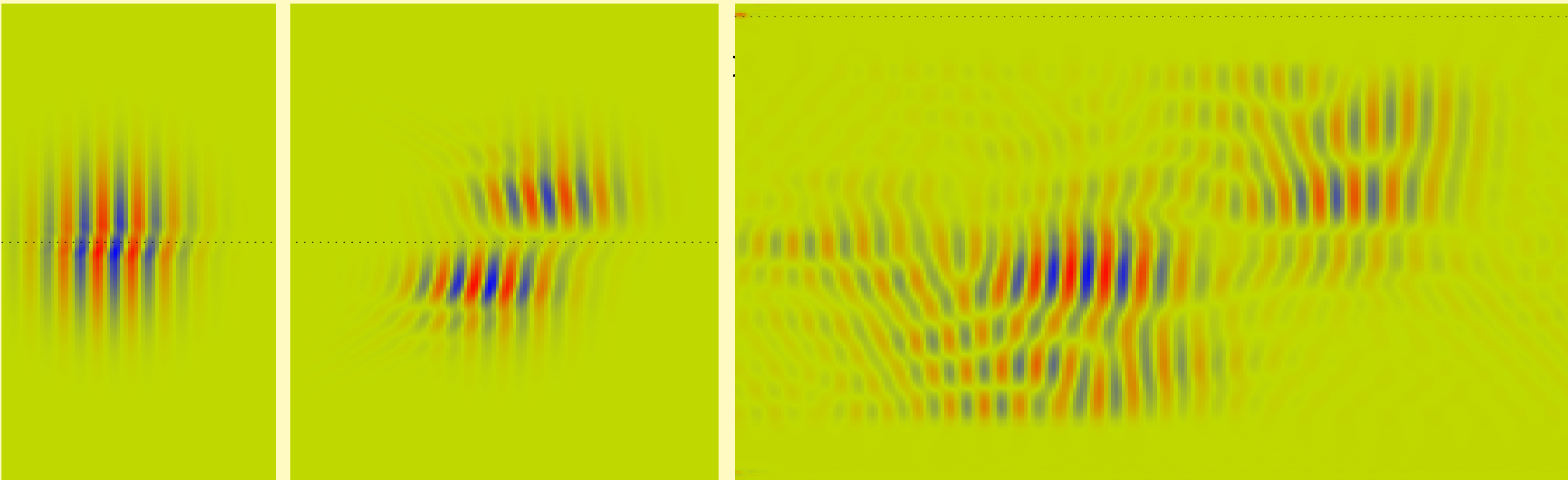
Snapshots of electric field $\vec{E}$ at three different times. Cylinder axis is marked with a dotted line, the top half shows a cross-section on the yz plane, while the bottom half shows a cross-section on the xz plane. Incident light is polarized along the x axis. Left: The Gaussian pulse just after entering the waveguide. Center: After a short time, a dark spot forms near the axis. Light near the xz and yz plane differs both in phase and propagation velocity. Right: After a longer time, reflection from waveguide walls cause noticeable interferrence and waveforms lose clarity.

Field intensity and phase

- Using data for electric and magnetic fields we calculated the local energy density. This enabled us to determine the shape of the pulse after a long time in the waveguide.

- We were also interested in planes of constant phase. By calculating the wave phase at every grid point, we determined that the initially Gaussian pulse quickly transforms into [še vedno ne vem kaj].