

Minimal Entropy Production in Nematic Liquid Crystals Subject to External Dissipative Fields Such as Temperature and Velocity Gradients

Sten Sarman^{C, S}

Department of Materials and Environmental Chemistry, Stockholm University, Stockholm, Sweden

sarman@ownit.nu

Due to the lower symmetry, transport phenomena in liquid crystals are much richer than in isotropic liquids. In axially symmetric nematic liquid crystals, where the molecules are approximately oriented in the same direction in space - the director - but where there is no translational order the heat conductivity has two independent components - parallel and perpendicular to the director - and the viscosity is a fourth rank tensor with seven independent components. Therefore, the heat flow and the shear stress and thereby the irreversible entropy production vary with the orientation of the director relative to a temperature gradient or a velocity gradient. Simulations of liquid crystal model systems consisting of soft ellipsoids have shown that the director tends to align perpendicularly to a temperature gradient. Since the heat conductivity is lower in the perpendicular direction than in the parallel direction this means that the heat flow is minimized. In shear flows at low shear rates in the linear Newtonian regime it has been observed both by theoreticians and by experimentalists that the director assumes an orientation angle that approximately minimizes the shear stress, even though this does not follow from the linear relation between the pressure and the velocity gradient. However, in planar elongational flow, where the system is elongated in one direction and contracted in the perpendicular direction, it follows directly from this linear relation that the director must orient either parallel or perpendicularly to the elongation direction because of mechanical stability and that the irreversible entropy production is either maximal or minimal in these orientations. Simulations have shown that the elongation direction is stable and that the irreversible entropy production is minimal in this orientation. Thus we have three examples where the director of a nematic liquid crystal subject to an external dissipative field assumes an orientation that minimizes the irreversible entropy production.