# Dissipative versus Reversible Contributions to Macroscopic Dynamics: Time-reversal Symmetry and Entropy Production

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We discuss the time-reversal behavior of dynamic cross-couplings among various hydrodynamic degrees of freedom in liquid crystal systems. Using a standard hydrodynamic description including linear irreversible thermodynamics we show that the distinct thermodynamic requirements for reversible and irreversible couplings lead to experimentally accessible differences. We critically compare our descriptions with those of existing standard continuum mechanics theories [1-3], where time-reversal symmetry is not adequately invoked. Despite the common belief, there are subtle differences between the two schools of describing the dynamics, even for simple liquid crystal. The motivation comes from recent experimental progress allowing to discriminate between the hydrodynamic description and the continuum mechanics approach.

This concerns the dynamics of Lehmann-type effects in chiral liquid crystals [4]. If both, the direct and the inverse Lehmann effect [5] is measured for the same system, one can verify that these effects are based on the irreversible, rather than the reversible part of the dynamics. A second example is the dynamic magneto-electric response in ferronematics and ferromagnetic nematics [6], a liquid multiferroic system. Here, the different behavior under time reversal of the nematic director and of the magnetization leads to characteristic, experimentally detectable features that have not been found by a continuum mechanics approach.

In addition, we discuss the consequences of time-reversal symmetry for flow alignment of the director in nematics (or pretransitional nematic domains) and for the dynamic thermomechanical and electro-mechanical couplings in textured nematic liquid crystals.

With the advent of ever more complicated liquid crystal and soft matter systems, like bentcore nematics or smectic liquid crystals, systems involving tetrahedral order [7], polar and magnetic liquids, polymers or elastomers, and of ordered active matter, it has become obvious that a thorough theoretical description based on thermodynamics is inevitable. Time reversal symmetry is an important element of that.

**References**

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