Theoretical Models for the Evaluation of Liquid Thermal Conductivity: Gas-Like Models vs. Solid-Like Models

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Theories of liquid states have lagged far behind those of gaseous state because of the strong interactions between particles and their state of disorder. In this review, we will consider that the de Broglie wavelength of each molecule is small if compared with the average distance between molecules. Such "classical liquids" obey classical mechanics and classical statistics.

Liquids and dense fluids are different from dilute gases, due to the importance of collisional processes and short-range interactions. In addition, they are different from solids because of the lack of long-range order. The development of accurate theories on the liquid state results in hard challenges, due to the lack of an idealized model comparable with the perfect gas or the harmonic solid, both of which can be treated with precision.

On the other hand, the somewhat intermediate role of the liquid state has played a great role in the understanding of liquid behavior, since most theories are "extrapolations" from "gas-like" or "solid-like" theories. Lattice theories, for example, overemphasize the solid-like character of liquids, whereas methods which rely on expansions in powers of the density allow for the systematic calculation of corrections to ideal-gas behavior. In any case, the two above approaches remain essentially theories of the imperfect gas and solid, respectively.

In this paper, we present a review of many theoretical approaches to the evaluation of liquid thermal conductivity based on gas-like and solid-like models. We focus our review on the applicability of the models to the evaluation of the thermal conductivity of organic liquids. Our main goal is to find a nexus between theories on heat and momentum transfer in liquids and empirical or semi-empirical models based on experimental evidence.