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EHD TURBULENCE IN CHANNEL FLOWS WITH INHOMOGENEOUS ELECTRICAL FIELDS: A ONE-DIMENSIONAL TURBULENCE STUDY

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Some aspects of the nature of turbulence are addressed in the research on electrohydrodynamic (EHD) flows which may be divided into two categories. In the first category EHD effects do not affect the flow although they may enhance specific properties of an application, like in EHD-enhanced heat exchangers [1]. In the second category EHD effects interact with the flow, like in the case of electrostatic precipitators [2] or for the purpose of flow control [3]. Here, the electrokinetics and the flow are affected by transient processes on all relevant scales so that robust, accurate, but also economical modeling strategies are required to tackle these flows. This is addressed here by utilizing the stochastic one-dimensional turbulence (ODT) model [4], which we have extended to incorporate EHD effects.

We apply ODT to two cases from the second category but distinguish a limiting 'adiabatic' regime (electrical fields in equilibrium) from the fully-coupled regime. For the 'adiabatic' regime, we consider a planar precipitator, which is given by a channel with wire electrodes in the mid plane. These electrodes yield a spatially inhomogeneous background electrical field that couples to the free charges in the working fluid. For the fully-coupled regime, we consider a planar channel with moving walls held at different voltages. The working fluid possesses positive and negative ion species so that charge separation enables electrical drift currents that may interact with the flow. Our results exhibit good to reasonable agreement with available references data for the mean and low-order fluctuation statistics, respectively. Our results furthermore suggest that it is important to capture the spatial structure of the electrical fields.

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