# EXTENSION OF THE ONE-DIMENSIONAL TURBULENCE MODEL TOWARDS ELECTROHYDRODYNAMIC VARIABLE DENSITY FLOWS

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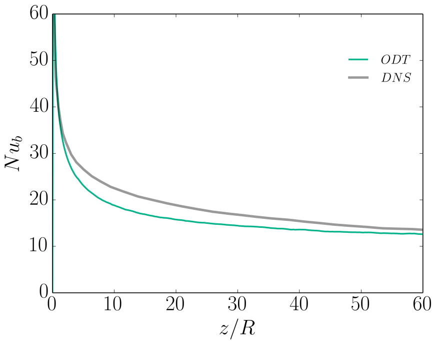
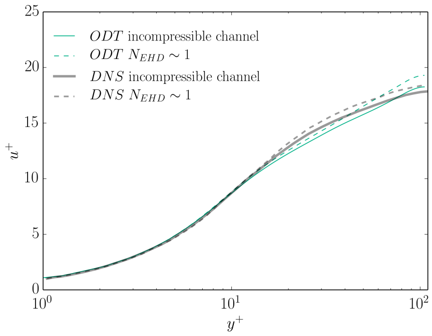
The unavailability of suitable closure models for electrohydrodynamic (EHD) flows makes numerical simulation research largely dependant on Direct Numerical Simulations (DNSs). Engineering studies also rely on Reynolds-Averaged Navier-Stokes (RANS) simulations in order to predict the flow dynamics, often with little success since the small scale physical processes, which have to be parameterized, are not fully understood. A possible alternative is to resort to stochastic turbulence approaches, e.g. the One-Dimensional Turbulence (ODT) model. In contrast to traditional turbulence modelling, where the modelling focuses on the characterization of certain smaller physical length scale effects, ODT is able to resolve all relevant physical scales on a reduced dimension [3, 4]. Physical insight can then be gained via detailed parameter studies, which are feasible due to the more economical computational power required.

In this study, a novel formulation for the ODT model is presented. The new approach is based on a previous variable density formulation for closed systems from [6], adapted to cylindrical coordinates [5], and recently extended to incorporate EHD effects as part of the eddy selection process in ODT [7]. The variable density formulation for closed systems has allowed reasonable results for characteristic streamwise heat transfer profiles in pipe flows. Preliminary results for the streamwise bulk Nusselt number profile, obtained with a spatial ODT formulation in a heated pipe flow configuration analogous to [2], are shown in Figure 1(a). The incorporation of EHD effects into the model has also allowed the analysis of incompressible velocity profiles under the influence of electrostatic body forces as in [9], see Figure 1(b). The new model formulation presented here aims to evaluate the heat transfer enhancement produced by EHD body forces in turbulent pipe flows. In this context, relations between the bulk Nusselt and Reynolds number, as well as the EHD number or the electric Reynolds number will be discussed and analysed, as in [8]. Results will also be presented and compared with recent experimental measurements [1]. This work is yet another contribution towards the milestone of achieving a fully consistent formulation for EHD flows in ODT.




(a)




(b)

**Figure 1.** (a) Streamwise bulk Nusselt number profile in a heated pipe configuration showing ODT and DNS data from [2] (case 618). (b) Normalized mean velocity profile for incompressible channel flow; ODT results are shown and compared to DNS data from [9] (reference and low $N_{EHD}$ electrohydrodynamic number case).

## References

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