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Stochastic modeling of heated turbulent coaxial pipe flow prescribing different thermal boundary conditions

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Transfer properties of heated turbulent concentric coaxial pipe flows are numerically investigated. A stochastic approach, the so-called one-dimensional turbulence model[1] (ODT) formulated for cylindrical geometry[2], is applied here as forward modeling tool. ODT is a dimensionally reduced flow model that makes it feasible to resolve all relevant turbulent scales of the flow along a single physical coordinate. This coordinate is here aligned with the radial direction as sketched in Fig. 1(a). The predictive capabilities of ODT for scalar and momentum transfer have been addressed recently from a fundamental point of view for plane channel[3] and heated low-Mach number pipe flow[4]. For the annular configuration considered here, radius ratios $\eta = R_i/R_o \geq 0.1$ are investigated. No-slip and uniform heat-flux wall boundary conditions are prescribed at the inner and outer cylinder wall, respectively. ODT predictions of low-order statistics are in reasonable agreement with reference DNS[5] as shown in Fig. 1(b). The friction-normalized mean temperature $\langle\Theta\rangle^+$ is composed of the diffusive sublayer $\langle\Theta\rangle^+ = Pr\, r^+$ and the log layer $\langle\Theta\rangle^+ = A' \ln r^+ + B'$, where $Pr = 0.71$ is the molecular Prandtl number of the working fluid, $A' = 2.86$ and $B' = 1.34$ for reference DNS[5]. ODT reasonably reproduces A', but overestimates B' for very low η. Present results suggest that ODT is capable of capturing the main characteristics of fluid flow in coaxial pipes, which is relevant for numerically aided heat exchanger design. In the contribution, we will address the ODT-based modeling of weakly heated coaxial pipe flows, emphasizing the dependence of the heat transfer on the radius ratio and the thermal boundary condition.

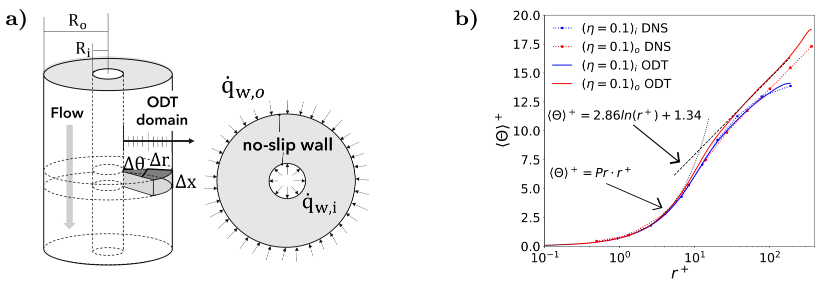

Figure 1: **a)** Schematic of the coaxial pipe flow configuration. **b)** Law-of-the-wall plot of the mean perturbation temperature $\langle\Theta\rangle^+$ for $\eta = 0.1$ at the inner *(blue)* and outer *(red)* cylinder wall compared to reference DNS [5].

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