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Multi-layer description of azimuthal velocity distribution in turbulent Taylor-Couette flow. HONG-YUE ZOU, ZHEN-SU SHE, SKLTCS, COE, Peking Univ. — A quantitative multi-layer theory is developed for accurate description of mean azimuthal velocity profile (MAVP) in turbulent Taylor-Couette flow (TCF), validated by both experimental and numerical data over a wide range of Reynolds numbers (Re). In particular, the observations of a logarithmic law in MAVP by Sun et. al. is obtained, based on a similarity argument between the azimuthal velocity (instead of angular velocity) in TCF with temperature in Rayleigh-Benard convection. The theory allows to extract accurate Re scaling of the thicknesses of sub-layer, buffer layer, log-layer, and a linear layer from the empirical data, which successfully explain the observed variation of the log-law coefficient κ from 0.32 for small Re to 0.40 for large Re. More interestingly, a linear layer is discovered in the MAVP far away from the wall, and an observed scaling of its coefficient A˜$\mathrm{Re}^{-0.65}$ is explained by the scaling of the log-layer thickness, and an observed torque scaling, G˜$\mathrm{Re}^{1.794}$, is explained by the scaling of the viscous sublayer, all validated by simulation data. In conclusion, the multi-layer thicknesses are shown to be important physical measures of the TCF.

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