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Structure Functions in Wall-bounded Flows at High Reynolds Number XIANG YANG, Johns Hopkins University, IVAN MARUSIC, University of Melbourne, PERRY JOHNSON, CHARLES MENEVEAU, Johns Hopkins University — The scaling of the structure function $D_{\mathrm{ij}} = <(u_{\mathrm{i}}(\mathbf{x}+\mathbf{r})-u_{\mathrm{i}}(\mathrm{x}))(u_{\mathrm{j}}(\mathbf{x}+\mathbf{r})-u_{\mathrm{j}}(\mathbf{x}))>$(where i =1,2,3 and $\mathbf{r}$ is the two-point displacement, u_i is the velocity fluctuation in the x_i direction), is studied in wall-bounded flows at high Reynolds number within the framework of the Townsend attached eddy model. While the scaling of D_{ij} has been the subject of several studies, previous work focused on the scaling of D_{11} for $\mathbf{r}$= (Δx,0,0) (for streamwise velocity component and displacements only in the streamwise direction). Using the Hierarchical-Random-Additive formalism, a recently developed attached-eddy formalism, we propose closed-form formulae for the structure functionD_{ij} with two-point displacements in arbitrary directions, focusing on the log region. The work highlights new scalings that have received little attention, e.g. the scaling of D_{ij} for $\mathbf{r}$=(0, Δy, Δz) and for $i \neq j$. As the knowledge on D_{ij} leads directly to that of the Reynolds stress, statistics of the filtered flow field, etc., an analytical formula of D_{ij} for arbitrary $\mathbf{r}$ can be quite useful for developing physics-based models for wall-bounded flows and validating existing LES and reduced order models.

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