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**Toroidal-helical pipe as a passive mixing and heat transfer device in laminar flows** CHENGUANG ZHANG, Massachusetts Institute of Technology, KRISHNASWAMY NANDAKUMAR, Louisiana State University & The Energy Research Institute, Jinan, PRC — The secondary flow of Dean vortex pair is a long-known mechanism for the enhancement of mixing and heat transfer, with example uses including circular or spiral pipes. We present a novel design of a toroidal helical pipe, which follows a three-dimensional toroidal helix (an analytical curve smoothly winding around a torus) as its pipe axis. Unlike the circle or straight helix which has constant curvatures, the toroidal helix has a spatially oscillating curvature. This unique feature causes the classic separated Dean vortex pair to couple, periodically re-orient, shrink and grow within each turn of the pipe. The complex flow pattern spans the entire cross-section and enhances mixing via advection. Using heat transfer as an example, the Nusselt number in the toroidal helical pipe varies periodically, with mean values several times higher than a straight pipe even at moderate Reynolds numbers.

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