The effects of freestream turbulence on cylinder wakes

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In this study, we examine the influence of freestream turbulence on the near and intermediate wake behind a circular and a square cylinder, which has broad scientific and engineering applications. Studies have shown that freestream turbulence can have significant effects on the wake velocity fluctuations, the unsteady drag, and the wake geometry[1,2,3]. The experiment uses an active grid to generate four different inflows, and planar particle image velocimetry is used to capture a continuous flow field from $0.6D$ to $20D$ downstream of the cylinder. The Reynolds number based on the cylinder diameter is $Re_D \approx 3.5 \times 10^4$.

Figure 1 shows that freestream turbulence appears to induce an earlier onset of self-similar behaviour, as seen by the closer approximations of U_s/U_0 and ℓ/D to the analytical solution as freestream turbulence intensity increases. In essence, the wake development is artificially "matured". In the near wake, the recirculation region behind the square cylinder is noticeably elongated as freestream turbulence intensity increases, which reduces the wake width in that region. Subsequent analysis will examine intermittency to quantify instantaneous extreme events in the wake, as well as using proper orthogonal decomposition to reveal more insight into the wakes' spatial features.

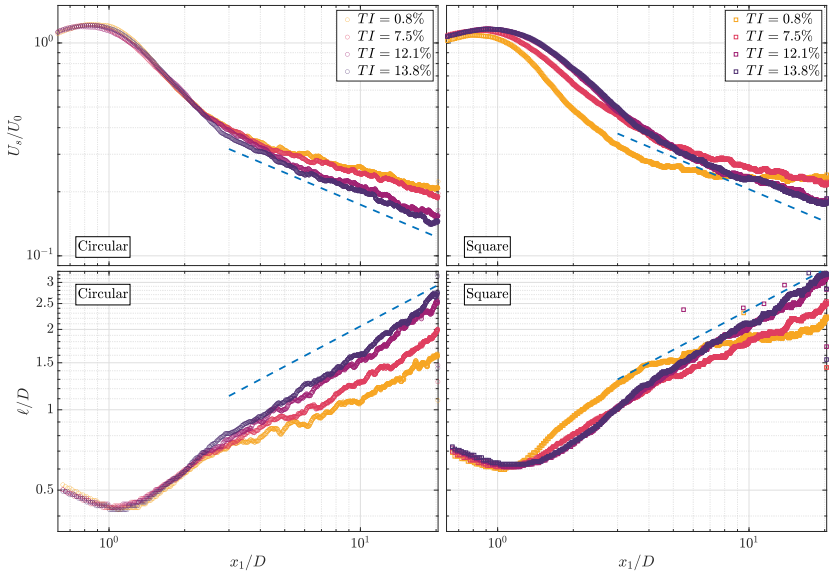

Figure 1: Streamwise profiles for all test cases for U_s/U_0 and ℓ/D. The blue lines in each plot denote the corresponding analytical solutions $U_s/U_0 \propto (x_1/D)^{-0.5}$ and $\ell/D \propto (x_1/D)^{0.5}$.

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[1]Britter et al., *J. Fluid Mech.* **92**, 269 (1979)
[2]Eames et al., *J. Turbulence* **12**, 1 (2011)
[3]Surry, *J. Fluid Mech.* **52**, 543 (1972)