Turbulent Flows
Stephen B. Pope
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Solution to Exercise 13.45

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From Eq.(13.285), we obtain $\langle \varepsilon_r \rangle = \frac{C_E}{\Delta} \langle k_r^{3/2} \rangle$. Now we assume that $\langle k_r \rangle^{3/2} \approx \langle k_r \rangle^{3/2}$. Based on Eq. (13.97), we can write

$$\varepsilon \approx \langle \varepsilon_r \rangle \approx \frac{C_E}{\Delta} \left[\frac{3}{2} C \left(\frac{\varepsilon \Delta}{\pi} \right)^{2/3} \right]^{3/2} . \tag{1}$$

Hence $C_E \approx \pi \left(\frac{3}{2} C \right)^{-3/2} \approx 0.93$.

Again we assume that $\langle k_r^{1/2} \bar{\mathcal{S}}^2 \rangle \approx \langle k_r \rangle^{1/2} \langle \bar{\mathcal{S}}^2 \rangle$. Then

$$\varepsilon \approx \langle \mathcal{P}_r \rangle \approx C_\nu \Delta \langle k_r \rangle^{1/2} \langle \bar{\mathcal{S}}^2 \rangle = \pi C_\nu \left(\frac{3}{2} C \right)^{3/2} \varepsilon, \tag{2}$$

wherefrom $C_\nu \approx \pi^{-1} \left(\frac{3}{2} C \right)^{-3/2} \approx 0.094$.