Equation T.3 corresponds to the original PANS model. Recall that the turbulent diffusion in, for example, the k equation reads

$$\frac{\partial}{\partial x_j}\left(\frac{\nu_t}{\sigma_k}\frac{\partial k}{\partial x_j}\right) \tag{T.4}$$

Since $f_k = 0.4$, it means that the turbulent diffusion in the k and ε equations are $1/0.4^2 \simeq 6$ times larger in [173] than in [207]. The consequence is that peaks in k and ε (and also ν_t) are reduced in the former case compared to the latter (this is the physical role played by diffusion: it transports k from regions of high k to regions of low k). This explains why the peaks of k are much larger in [207] compared to in [173].

Hence, in the original PANS model (Eq T.3), the RANS turbulent viscosity appears in the turbulent diffusion of k (and ε), because the turbulent diffusion term reads (recall that $f_k = k/k_{total} = k/k_{RANS}$ where k_{RANS} denotes the turbulent kinetic energy in a RANS simulation)

$$\begin{aligned}\frac{\partial}{\partial x_j}\left(\frac{\nu_t}{f_k^2\sigma_k}\frac{\partial k}{\partial x_j}\right) &= \frac{\partial}{\partial x_j}\left(\frac{c_\mu k^2}{\varepsilon f_k^2\sigma_k}\frac{\partial k}{\partial x_j}\right)\\ = \frac{\partial}{\partial x_j}\left(\frac{c_\mu k_{RANS}^2}{\varepsilon\sigma_k}\frac{\partial k}{\partial x_j}\right) &= \frac{\partial}{\partial x_j}\left(\frac{\nu_{t,RANS}}{\sigma_k}\frac{\partial k}{\partial x_j}\right)\end{aligned} \tag{T.5}$$

cf. Eqs. 18 and 19 in [145]. Thus the *total* (i.e. RANS) viscosity is responsible for the transport of the *modeled* turbulent kinetic energy.

T.4 Location of interface

The results analyzed above were from LES simulations [173, 207] (i.e. the PANS model was used in LES mode). Now we will analyze results from PANS where f_k is computed. In [169, 218] f_k is computed based on the DES model. We will use data obtained from this model but on a finer mesh and larger domain than in [169, 218]. Here we call the model D-PANS.

Run the file `pl_vect_hump_fine.py` (Python) or `pl_vect_hump_fine.m` (MAtlab/Octave) which loads the file `vectz_fine.dat`, `xy_hump_fine.dat`, and `x065_off.dat`. This mesh has $649 \times 110 \times 32$ cells with $Z_{max} = 0.2$ (the mesh is plotted in `pl_vect_hump_fine`). Recall that $\Delta z = 0.2/32$. Start by finding where the PANS model predicts the switch from RANS to LES (i.e where f_k goes from one down to, say, 0.4). f_k is computed in Eq. 16 in [169]. Plot location of the switch (the wall distance) versus x.

Plot f_k also at a couple of x_1 locations $(0.65 \ldots 1.30)$. Is it bigger or smaller than the prescribed values $(0.4$ and $1)$? Compare it also with the definition of $f_k = k/k_{total}$ (cf. Fig. 26 in [165]).

In [219], f_k is computed as

$$f_k = c_\mu^{-1/2}\left(\frac{\Delta}{L_t}\right)^{2/3}, \quad L_t = \frac{k_{total}^{3/2}}{\langle\varepsilon\rangle} \tag{T.6}$$

Compare this f_k with f_k with D-PANS.

T.5 Location of interface in DES and DDES

Let's compare D-PANS with DES and DDES. In SA-DES, the interface is defined as the location where the wall distance is equal to $C_{DES}\Delta$ where $\Delta = \max\{\Delta_x, \Delta_y, \Delta_z\}$, see Eq. 20.3. How does this compare with switching locating defined by D-PANS?