

## Equations of motion of the fluid phase

- statistically stationary, incompressible and isothermal fluid flow
- constant physical properties of the fluid flow; Newtonian fluid
- 3-dimensional, time-averaged form of transport equations :

$$\frac{\partial}{\partial x}(\rho_F u_F \Phi) + \frac{\partial}{\partial y}(\rho_F v_F \Phi) + \frac{\partial}{\partial z}(\rho_F w_F \Phi) = \\ \frac{\partial}{\partial x}\left(\Gamma_\Phi \frac{\partial \Phi}{\partial x}\right) + \frac{\partial}{\partial y}\left(\Gamma_\Phi \frac{\partial \Phi}{\partial y}\right) + \frac{\partial}{\partial z}\left(\Gamma_\Phi \frac{\partial \Phi}{\partial z}\right) + S_\Phi + S_\Phi^P$$

- Source terms and transport coefficients for various variables  $\Phi$  :

| $\Phi$  | $S_\Phi$   | $S_\Phi^P$  | $\Gamma$                           |
|---|--|-------------|------------------------------------|
| 1   | 0  | 0           | 0                                  |
| $u_F$   | $\frac{\partial}{\partial x}\left(\Gamma_\Phi \frac{\partial u_F}{\partial x}\right) + \frac{\partial}{\partial y}\left(\Gamma_\Phi \frac{\partial v_F}{\partial x}\right) + \frac{\partial}{\partial z}\left(\Gamma_\Phi \frac{\partial w_F}{\partial x}\right) - \frac{\partial p}{\partial x} + \rho_F f_x$ | $S_{u_F}^P$ | $\mu_{eff}$                        |
| $v_F$   | $\frac{\partial}{\partial x}\left(\Gamma_\Phi \frac{\partial u_F}{\partial y}\right) + \frac{\partial}{\partial y}\left(\Gamma_\Phi \frac{\partial v_F}{\partial y}\right) + \frac{\partial}{\partial z}\left(\Gamma_\Phi \frac{\partial w_F}{\partial y}\right) - \frac{\partial p}{\partial y} + \rho_F f_y$ | $S_{v_F}^P$ | $\mu_{eff}$                        |
| $w_F$   | $\frac{\partial}{\partial x}\left(\Gamma_\Phi \frac{\partial u_F}{\partial z}\right) + \frac{\partial}{\partial y}\left(\Gamma_\Phi \frac{\partial v_F}{\partial z}\right) + \frac{\partial}{\partial z}\left(\Gamma_\Phi \frac{\partial w_F}{\partial z}\right) - \frac{\partial p}{\partial z} + \rho_F f_z$ | $S_{w_F}^P$ | $\mu_{eff}$                        |
| $k$   | $P_k - \rho_F \varepsilon$   | 0           | $\frac{\mu_t}{\sigma_k}$           |
| $\varepsilon$   | $\frac{\varepsilon}{k}(c_{\varepsilon_1} P_k - c_{\varepsilon_2} \rho_F \varepsilon)$  | 0           | $\frac{\mu_t}{\sigma_\varepsilon}$ |
| $P_k = \mu_t \left\{ 2 \cdot \left[ \left( \frac{\partial u_F}{\partial x} \right)^2 + \left( \frac{\partial v_F}{\partial y} \right)^2 + \left( \frac{\partial w_F}{\partial z} \right)^2 \right] + \left( \frac{\partial u_F}{\partial y} + \frac{\partial v_F}{\partial x} \right)^2 + \left( \frac{\partial u_F}{\partial z} + \frac{\partial w_F}{\partial x} \right)^2 + \left( \frac{\partial w_F}{\partial y} + \frac{\partial v_F}{\partial z} \right)^2 \right\}$ |  |             |                                    |
| $\mu_{eff} = \mu + \mu_t , \quad \mu_t = \rho_F c_\mu \frac{k^2}{\varepsilon}$  |  |             |                                    |
| $c_\mu = 0.09 , \quad c_{\varepsilon_1} = 1.44 , \quad c_{\varepsilon_2} = 1.92 , \quad \sigma_k = 1.0 , \quad \sigma_\varepsilon = 1.3$  |  |             |                                    |

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| 3 | <b>ASME Fluids Eng. Division Summer Meeting</b><br><b>A 3-dimensional Lagrangian Solver for Disperse Multiphase</b><br><b>Flows on Geometrically Complex Flow Domains</b><br>Th. Frank, E. Wassen, Q. Yu, Technical University Chemnitz, Germany |  |
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