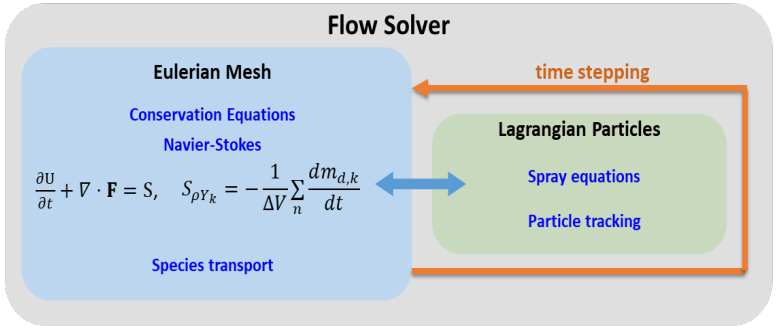
室内環境におけるウイルス飛沫感染の予測とその対策：富岳大規模解析に向けたケーススタディ

（1）飛沫モデルの開発

- 飛沫モデルには自動車エンジン内燃焼に用いる噴霧モデルを改良

気流・飛沫連成シミュレーションと飛沫モデルの概要



$\overline{W}$ - Average molecular wt of the gas phase
W_V - Molecular wt of water vapor
P_{sat} - Saturated vapor pressure
$Y_{V,s}$ - Vapor surface mass fraction
Y_V - mass fraction of vapor in the far field.
$X_{V,s}$ -Mole fraction of vapor at droplet surface
Sc – Schmidt number
Pr – Prandtl number

Particle Motion Model

$$\frac{d\mathbf{x}_d}{dt} = \mathbf{u}_d, \quad \frac{d\mathbf{u}_d}{dt} = \frac{6}{8}\frac{\rho_g}{d_d \rho_d}|\mathbf{u} - \mathbf{u}_d|(\mathbf{u} - \mathbf{u}_d)C_d$$

$$C_d = \begin{cases} 0.424 & \mathrm{Re}_p > 1000 \\ \frac{24}{\mathrm{Re}_p}\left(1 + \frac{1}{6}\mathrm{Re}_p^{2/3}\right) & \mathrm{Re}_p \le 1000 \end{cases}$$

$$Re_p = \frac{\rho_g |\mathrm{u} - \mathrm{u_d}| \mathrm{d_d}}{\mu}$$

Evaporation Model

$$\frac{dT_d}{dt} = \frac{Nu}{3Pr}\left(\frac{c_p}{c_l}\right)\left(\frac{f_2}{\tau_d}\right)(T - T_d)\frac{1}{m_d}\left(\frac{dm_d}{dt}\right)\frac{L_V}{c_{p,d}}$$

$$\dot{m}_d = -\frac{m_d}{\tau_d}\left(\frac{Sh}{3Sc}\right)\ln(1 + B_M)$$

$$Nu = 2 + 0.552 Re_s^{1/2} Pr^{1/3}$$

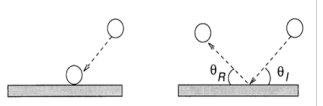
$$Sh = 2 + 0.55 Re_s^{1/2} Sc^{1/3}$$

$$B_M = \frac{Y_{V,s} - Y_V}{1 - Y_{V,s}} \qquad \tau_d = \frac{\rho_d d_d^2}{18\mu}$$

$$Y_{V,s} = \frac{X_{V,s}}{X_{V,s} + (1 - X_{V,s})\overline{W}/W_V} \qquad X_{V,s} = \frac{P_{sat}}{P}$$

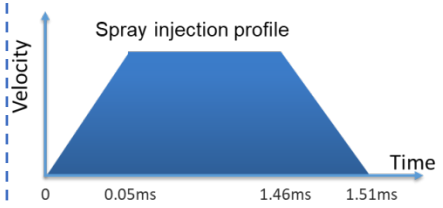
Wall Reflection Model

Regime transition state	Critical Weber number
Adhesion (stick/spread) → splash	$We_c \approx 2630 \cdot La^{-0.183}$



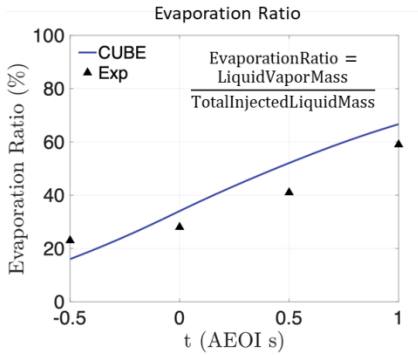
$We = \rho V_N^2 d_I / \sigma$ $La = \rho \sigma d_I / \mu^2$

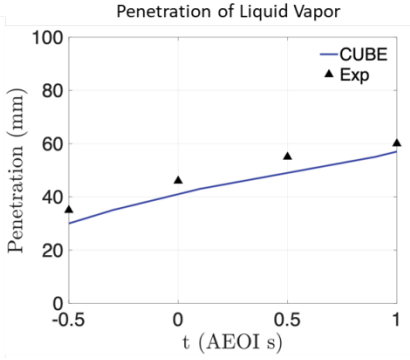
モデルの検証（自動車エンジン噴霧モデル）

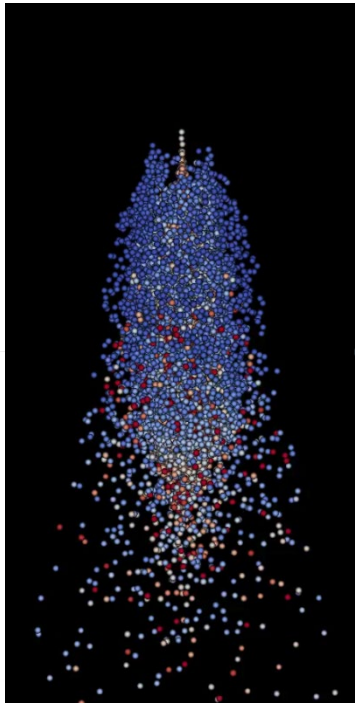


Ambient Condition	
Ambient Gas	Nitrogen
T_a [K]	500
P_a [MPa]	1.0

Injection Condition		
Fuel	p-Xylene	MEK
Injector	Single Hole	
Hole Diameter [mm]	0.15	
Injection Pressure [MPa]	10	
Injection Duration [ms]	1.51	
Injection Quantity [mg]	1.68	1.78







（2）発話・歌唱・咳モデルの開発

- 飛沫粒径分布と呼気流量の時間変化を境界条件として設定
- 会話，歌唱はone, two, …., tenを5.5秒で発話し，それを繰り返す