

Namelist "Radiative_Heat_Transfer_DOM"

This data set is used to define the radiative problem. Otherwise, it can be omitted. This module considers the Radiative Transfer Equation (RTE) for an emitting-absorbing non-scattering medium enclosed by diffuse boundaries. To take into account the gas behavior, it considers both gray-gas assumption as well as real gas behavior through the Spectral-Line-Weighted-Sum-of-Gray-Gases (SLW) model. The final RTE-SLW problem is then discretized with the Discrete Ordinates Method (DOM).

The DOM discretizes the 4π steradians angular integration in a set of M discrete directions represented by their direct cosines and corresponding weights $\vec{q}_m = (\vec{s}_m, \omega_m) = (\mu_m, \eta_m, \xi_m, \omega_m)$ for all $m \in [1, M]$.

The SLW model will change the spectral integration in a weighted sum of N_g gray-gases represented by their absorption coefficient and corresponding weights (κ_j, a_j) for all $j \in [1, N_g]$.

Thus, the resulting **RTE-SLW-DOM** problem for emitting-absorbing non-scattering medium stands as below :

$$\vec{s}_m \cdot \nabla I_j^m(x_i, \vec{s}_m) = \kappa_j \left[a_j I_b(T)(x_i) - I_j^m(x_i, \vec{s}_m) \right] \quad \forall (m, j) \in [M, N_g]$$

where I_j^m is the radiative intensity for the virtual gray-gas j in direction m and I_b is the blackbody radiative intensity and (κ_j, a_j) .

The **dimensional** radiative source term S_r and the boundary net radiative heat flux q_r^{net} are defined as :

$$S_r(x_i, T) = - \sum_{j=0}^{N_g} \kappa_j \left[\sum_{m=1}^M \omega_m I_j^m(x_i, \vec{s}_m) - 4 a_j \sigma_B (T)(x_i)^4 \right]$$

$$q_r^{\text{net}}(x_i^{\text{wall}}) = \epsilon_{\text{wall}} \left[\sigma_B (T)(x_i^{\text{wall}})^4 - \sum_{j=0}^{N_g} \sum_{m: \vec{s}_m \cdot \vec{n} > 0} \omega_m |\vec{s}_m \cdot \vec{n}| I_j^m(x_i^{\text{wall}}, \vec{s}_m) \right]$$

where σ_B is the Stefan-Boltzmann constant, ϵ is the boundary emissivity and $\vec{n}$ is the normal to the wall pointing out of the domain.



This radiative solver implementation considers only **3D cartesian** problems under **MPI cartesian domain decomposition** approach.

Full data set of the namelist

```
&Radiative_Heat_Transfer_DOM activateRadiation = .false., RadiativePeriod
= 1, FirstIterations = 20,
      RadiativeLocalIterations = 1, RadiativeConvergenceTolerance =
1.E-15,
```

```
WallRadcoeff = 1.0 , VolRadCoeff = 1.0, RadiativeScheme =  
"STEP",  
    ActivateGas = .false., NbGas = 1, ka_max = 0.0, ka_min = 0.0,  
    Pref = 101325.0, Tref = 300., Href = 1, spec = "H2O", xaref =  
0.07, xaUniform = 0.07,  
    Squad = 8, WallEmissivity = 0.0 0.0 0.0 0.0 0.0 0.0 /
```

Definition of the data set for the RTE problem

activateRadiation

- Type : Boolean value
- This option activates the radiative module.
 - .false. : no radiation considered
 - .true. : radiation problem is considered
- Default value = .false.

RadiativePeriod

- Type : Integer value
- This option set the periodicity of resolution of the Radiative problem in time iteration.
- Default value = 1

FirstIterations

- Type : Integer value
- In the case that no restart fields are available (start radiation from scratch), the solver will iterates "FirstIterations" times before entering the time loop.
- Default value = 20

RadiativeLocalIterations

- Type : Integer value
- Number of sub-iteration for the RTE solving at each radiative iteration.
- Default value = 1

RadiativeConvergenceTolerance

- Type : Real value
- Convergence criteria on the wall Fluxes and radiative source term for the sub-iteration.
- Default value = 1.E-15

WallRadcoeff

- Type : Real value
- Prescaler on the net radiative heat flux at walls.
- **For debugging only.**
- Default value = 1.0

VolRadcoeff

- Type : Real value
- Prescaler on the radiative source term.
- **For debugging only.**
- Default value = 1.0

RadiativeScheme

- Type : Character string with a maximum size of 20
- Name of the interpolation scheme used in the Discrete Ordinates Method.
- Available values :
 - "STEP" : first order interpolation scheme (robust)
 - "DIAMOND" : second order centered interpolation scheme (could lead to negative intensity)
 - "LATHROP" : second order interpolation scheme with limiter (time-consuming)
- Default value = "STEP"

SQuad

- Type : Integer value.
- Order N of the level symmetric angular quadrature (S_N)
- This quadrature leads to $M = (N+2) \times N$ directions in volume and half at boundaries
- Available values are 2, 4, 6, 8, 10, 12, 14
- Default value = 8

Tref

- Type : Real value.
- Reference temperature T_{ref} .
- Default value = Fluid_Properties%Reference_Temperature

Href

- Type : Real value.
- Reference Length H_{ref} .
- Default value = Nondimensionalization%Reference_Length

WallEmissivity

- Type : Real array of size 6.
- Boundaries emissivities ϵ sorted as (x-,x+,y-,y+,z-,z+).
- Default values = 0.0 0.0 0.0 0.0 0.0 0.0

Definition of the data set for the SLW model

activateGas

- Type : Boolean value
- This option activates the SLW module.
 - .false. : **transparent medium** under gray-gas assumption is considered (i.e. $\kappa = 0$)
 - .true. : Gas absorption and emission is considered
- Default value = .false.



if **activateGas == .false.**, the settings below are unnecessary.

NbGas

- Type : Integer value
- This option sets the number of weighted gray-gases N_g used in the SLW model.
 - NbGas = 1 : gray-gas assumption with $\kappa = \kappa_{min}$
 - NbGas ≥ 2 : SLW model is employed
- Default value = 1

ka_min , ka_max

- Type : Real values
- These options set the lower and upper bounds of absorbing coefficient for the SLW model.
 - if NbGas = 1 : $\kappa = \kappa_{min}$, **ka_max is useless**
 - if NbGas ≥ 2 : $\kappa_{min} < \kappa_j < \kappa_{max}$ for all $j \in [1, N_g]$
- Default value = [κ_{min} , κ_{max}] = [0.0 , 0.0]

SPECA

- Type : Character string with a maximum size of 3
- Name of the absorbing species when NbGas ≥ 2 (SLW model).

- Available values :
 - "H2O" : \$air-H_2O\$ mixture
 - "CO2" : \$air-CO_2\$ mixture
- Default value = "H2O"

xaref

- Type : Real value
- This option set the reference molar fraction x_{ref} of the absorbing species for the SLW model.
 - if "NbGas" $\$=\$ 1$: useless
- Default value = 0.07

xaUniform

- Type : Real value
- As long as the SLW model is not coupled with species equations, this option set a uniform molar fraction x_a of the absorbing species in the overall domain.
 - if NbGas $\$=\$ 1$: useless
- Default value = 0.07

Pref

- Type : Real value.
- Reference pressure P_{ref} .
- Default value = obtained from Fluid_Properties quantities

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