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 difuse 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 discretize with the Discrete Ordinates Method (DOM).

The DOM discretize 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] $

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

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, speca = "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

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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

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Definition of the data set for the SLW model

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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 κ = *ka_min*
  - NbGas $\ge$ 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 : κ = *ka_min*, ***ka_max* is useless**
  - if NbGas $\ge$ 2 : *ka_min* < κ_j < *ka_max* for all $j \in [1,N_g]$
- Default value = [ka_min , ka_max] = [0.0 , 0.0]

SPECA

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

- Available values :
  - “H2O” : $air-H_2O$ mixture
  - “CO2” : $air-CO_2$ mixture
- **if “NbGas” $=$ 1 : useless**
- 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}.
  - **if “NbGas” $=$ 1 : useless**
- Default value = obtained from Fluid_Properties quantities