DROPIT

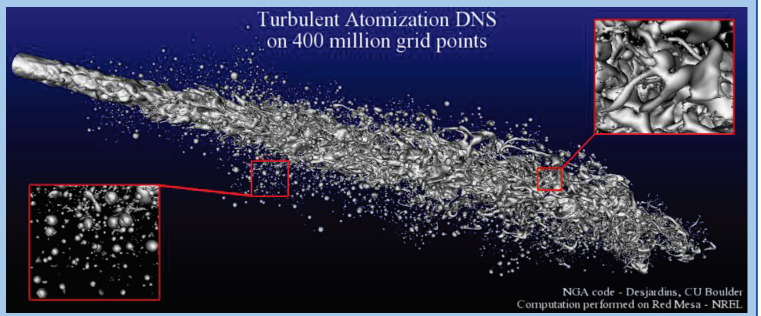
THEMATIC AREA A
DROP-GAS INTERACTION

FOCUS: MODELLING OF DROP VAPORISATION

GOAL: To derive basic models for drop vaporisation accounting for the effects of droplet deformation, compressibility and local non-equilibrium

List of planned sub-projects (principal investigators):

- SP-A1: Modelling of Deformed, Multi-Component Liquid Drop Evaporation
  (G. Cossali, S. Tonini, B. Weigand)
- SP-A2: Multi-scale Modelling of the Evaporation Process
  (C.-D. Munz, C. Rohde, M. Dumbser)
- SP-A3: Gas-kinetic Simulation of Microdroplet - Gas Interaction
  (S. Fasoulas, G. Lamanna, F. Bassi)
- SP-A4: Numerical Methods for Compressible Multi-phase Flows with Complex Equations of State
  (M. Dumbser, C.-D. Munz)
- SP-A5: Modelling of Spray Evaporation
  (G. Cossali, S. Tonini, V. Schleper)
- SP-A6: Mathematical and Numerical Modelling of Droplet Dynamics in Weakly Compressible Multi-Component Flows
  (V. Schleper, A. Beck, F. Bassi)



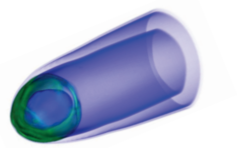
Direct numerical simulation of turbulent liquid atomization [1].

SP-A1: Modelling of Deformed, Multi-Component Liquid Drop Evaporation

GOAL: Predictive analytical and numerical tools capable of analysing the effect of particle shape and composition on transport processes

METHODS:

- Heat and mass transfer from complex particle shapes
- Non-constant properties and second order effects
- Species interaction modelling
- Multi-component deformed particle modelling
- Validation with available experimental data
- Convective effects on transport phenomena from deformed particles

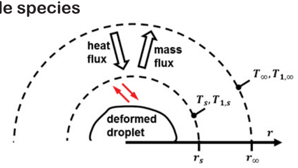

Evaporating drop example with iso-surfaces [2].

SP-A2: Multi-scale Modelling of the Evaporation Process

GOAL: Numerical method that allows a detailed investigation of interfacial phenomena

METHODS:

- Study evaporation processes at non-spherical, multi-component droplets and compare results with analytical (SP-A1) and numerical (SP-A5) investigations
- Extend current evaporation models for multiple species
- Improve EOS tabulation method for nearly incompressible fluids at ambient conditions
- Comparison of the sharp interface approximation to the diffuse interface approximation in SP-A4 with complementary validation

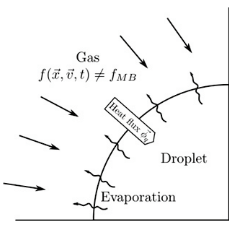


SP-A3: Gas-kinetic Simulation of Microdroplet - Gas Interaction

GOAL: Analysis of the influence of different gas phase distribution functions on the resulting fluxes on a (micro)droplet

METHODS:

- Implementation of an evaporation boundary condition
  - Adapt boundary conditions from SP-A2 and SP-A4 for DSMC method
  - Add new microscopic boundary condition
- Numerical modelling of the droplet deformation
  - Investigate moving mesh and level set method
  - Determine best method for DSMC framework
- Simulation of the gas - droplet interaction using the advanced DSMC method



SP-A4: Numerical Methods for Compressible Multi-phase Flows with Complex Equations of State

GOAL: Improved resolution of material interface within the diffuse interface approach by one order of magnitude compared to existing standards

METHODS:

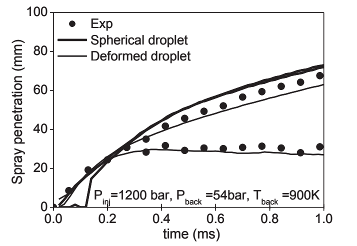
- Extend current high order DG method with a posteriori subcell limiting
- Include efficient tabulated EOS approach (SP-A2)
- Apply new schemes to isolated droplets and to droplet-droplet interactions
- Compare new diffuse interface approach to sharp interface approach

SP-A5: Modelling of Spray Evaporation

GOAL: Comprehensive predictive tool for mass and energy transfer in sprays under conditions typical of combusting environments

METHODS:

- Transfer models for single droplets from SP-A1
- Model the effect of neighbouring evaporating drops on vapour diffusion characteristics
- Implement model in CFD codes
- Predict real test case scenarios



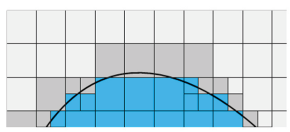
Effect of droplet deformation on the temporal variation of liquid and vapour penetration in a Diesel spray [3].

SP-A6: Modelling of Droplet Dynamics in Weakly Compressible Multi-Component Flows

GOAL: Reliable sharp interface models for weakly compressible dynamics of droplet-gas interactions with multiple components

METHODS:

- Development and analysis of coupling conditions for droplet - gas flow with multiple components
- Development of numerical methods for compressible / weakly compressible, compressible / incompressible and weakly compressible / incompressible multi-component multi-phase flows
- Integration of Maxwell-Stefan type diffusion
- Comparison with fully incompressible or compressible simulations (SP-A1, SP-A2)


Sketch of the computational grid.
Blue: liquid phase. Grey: gaseous phase.

References

[1] Desjardins et al., http://cmes.colorado.edu/gallery.html, last accessed February 3, 2016.
[2] Karch et al., Comput. Graphics Forum 31, 2012.
[3] Tonini et al., Int. J. Therm. Sci, 2009.

Research Training Group 2160/1: Droplet Interaction Technologies

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