

Development of an open spray model for the FLUENT framework

To overcome the limitations of the FLUENT built-in spray models, an open model structure has been developed that offers extended breakup and drag models, vaporization laws and collision models.

For secondary breakup, the TAB and KH-model already integrated in FLUENT have been reimplemented. The open model structure allows applying both models simultaneously, i.e. the TAB models for low Weber number droplets and the KH model for high Weber number droplets. Aside from these standard models, additional models have been implemented, e.g. a very recent phenomenological model by Chryssakis and Assanis [1], and a mixed physical-phenomenological model by Reichelt [2]. All breakup models are implemented with their corresponding drag laws. The vaporization models are based on heat and mass transfer laws by Sirignano [3]. The collision models are based on O'Rourke- and NTC-algorithms [4,5] and account for all collision regimes (coalescence, stretching separation, reflexive separation and bouncing). Coupling between the models has been extended over the standard FLUENT models; e.g. the vaporization models account for drop deformation and the collision model directly influences secondary breakup. In this presentation, the focus is put on technical aspects of the model implementation.

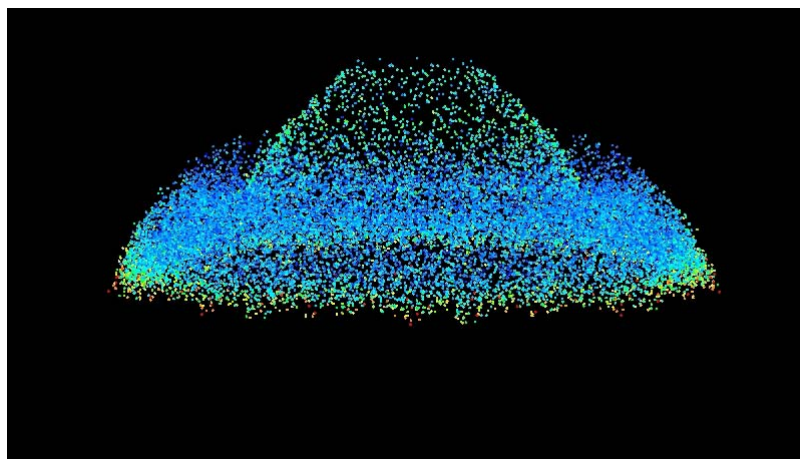
- [1] Chryssakis, C. and Assanis, D.N., A Unified Fuel Spray Breakup Model for Internal Combustion Engine Applications, *Atomization and Sprays* 18, 375-426, 2008.
- [2] Reichelt, L., *Aerodynamischer Tropfenzerfall bei dieselmotorischen Umgebungsbedingungen*, PhD Thesis, RWTH Aachen University, 2004.
- [3] Sirignano, W.A., *Fluid Dynamics and Transport of Droplets and Spray*, Cambridge University Press, 1999.
- [4] O'Rourke, P.J., *Collective Drop Effects on Vaporizing Liquid Sprays*, PhD Theses, Princeton University, 1981.
- [5] Schmidt, D.P. and Rutland, C.J., A New Droplet Collision Algorithm, *Journal of Computational Physics* 164, 62-80, 2000.

Implementation of an Open Spray Model for the FLUENT Framework

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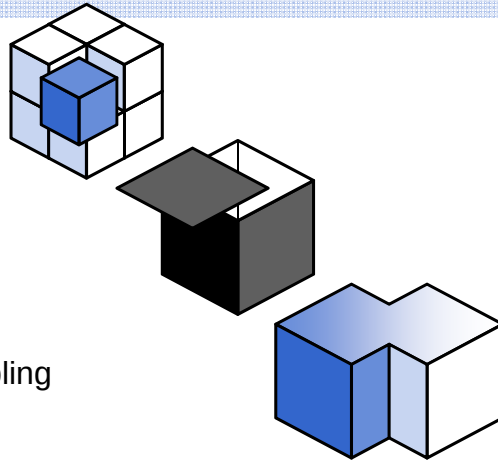


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Advantages of an Open Model Structure

- Extensibility
- Open the Black-Box
- Smooth Model-Coupling

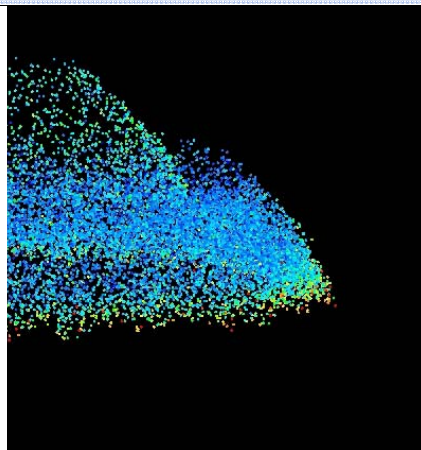


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Sub-Models Implemented

- Primary and **Secondary Breakup**
- **Collision and Coalescence**
- Collision-Breakup-Coupling
- Phase-Coupling
- Vaporization

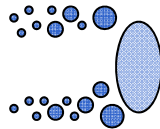


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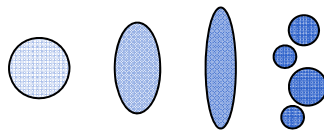
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Secondary Breakup Hybrid KH-TAB-Model

- KH Model for high Weber numbers ($80 < We < 800$)



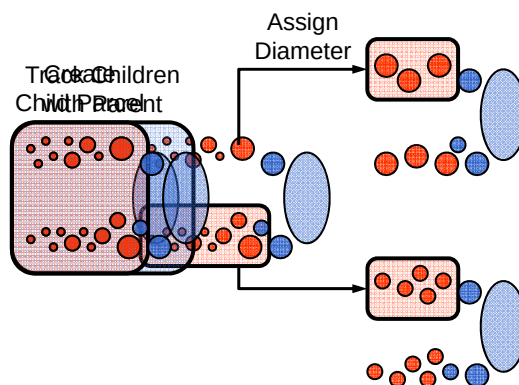
- TAB Model for low Weber numbers ($12 < We < 80$)



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Secondary Breakup KH-Model Implementation



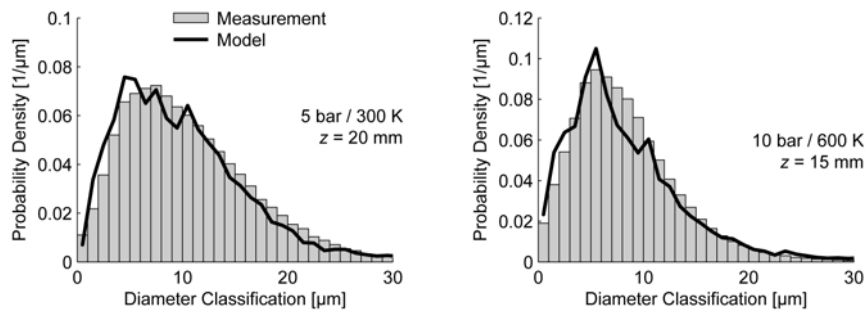
KH-Model Keeps Track of Mean Properties



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Secondary Breakup Hybrid KH-TAB-Model: Drop Size Validation



P. Pischke, D. Martin, R. Kneer, Combined Spray Model for GDI Hollow-Cone Sprays, AaS 20(4) 2010

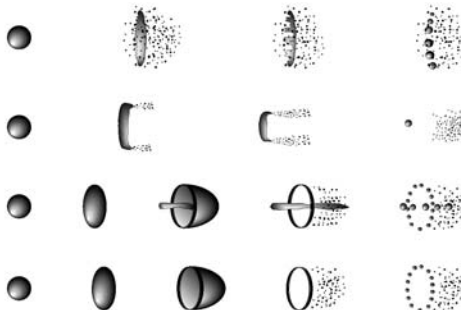


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Secondary Breakup Unified Breakup Model

- One Secondary Breakup Model for all Engine Sprays (C. Chrysosakis, D. Assanis)



Pilch, Erdmann (1987)

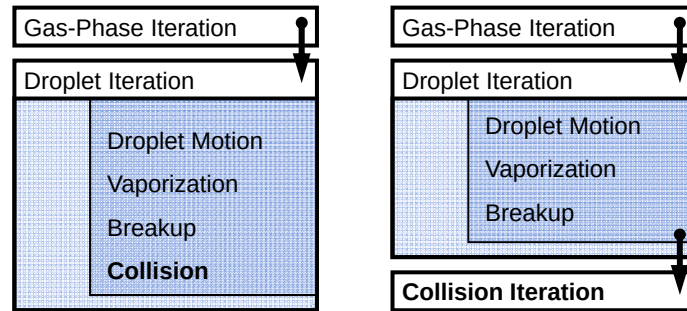


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Collision and Coalescence Model

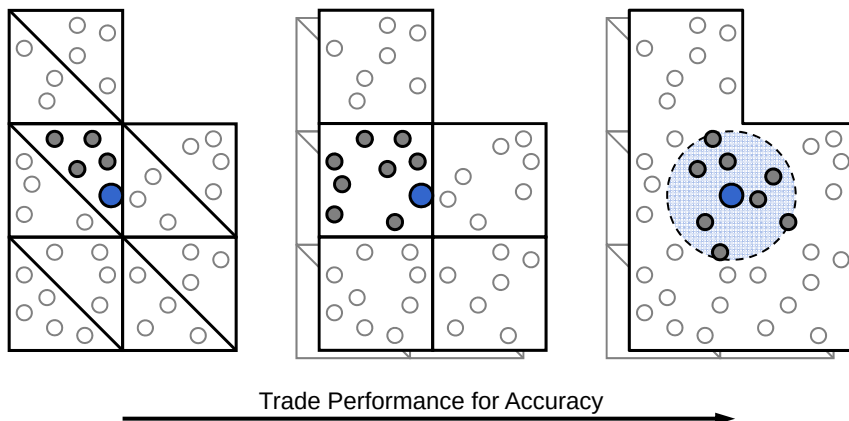
Introduction of a dedicated Collision Iteration



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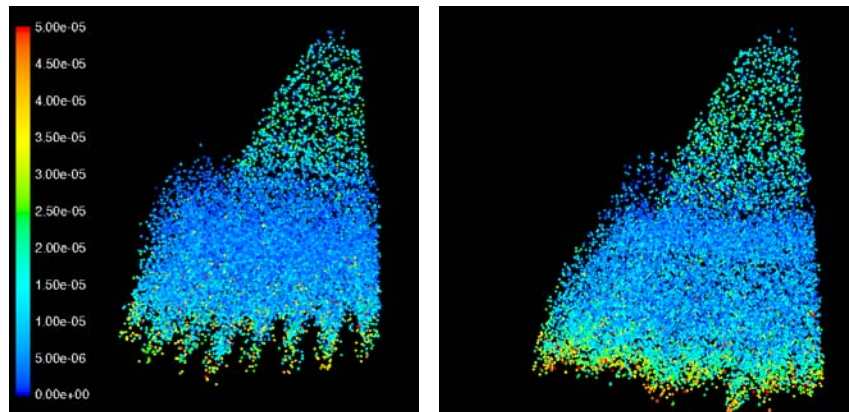
Collision and Coalescence Model Search Schemes



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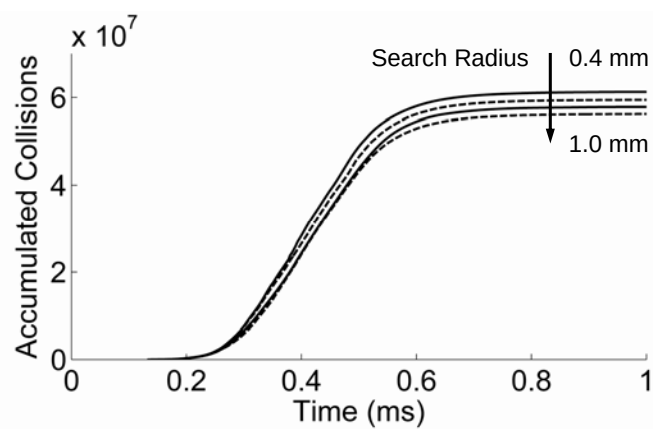
Collision and Coalescence Model Search Scheme Artifacts



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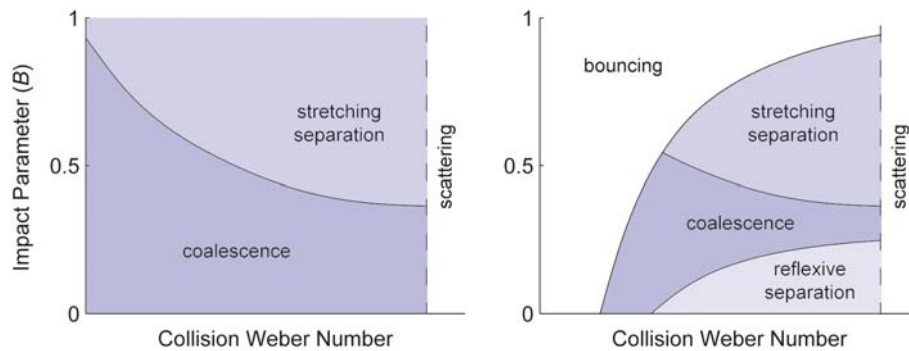
Collision and Coalescence Model Search Radius Dependency



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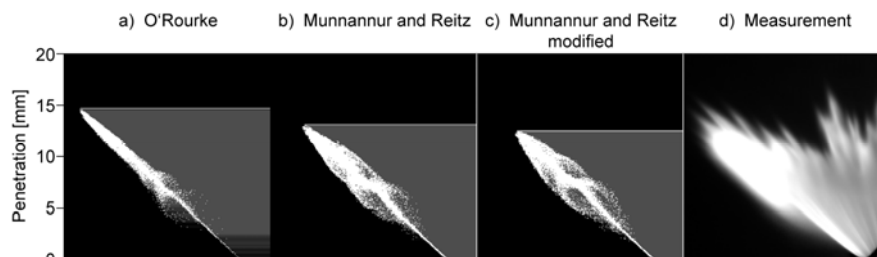
Collision and Coalescence Model Two- and Four-Regime Model



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Collision and Coalescence Model Modified Four-Regime Model



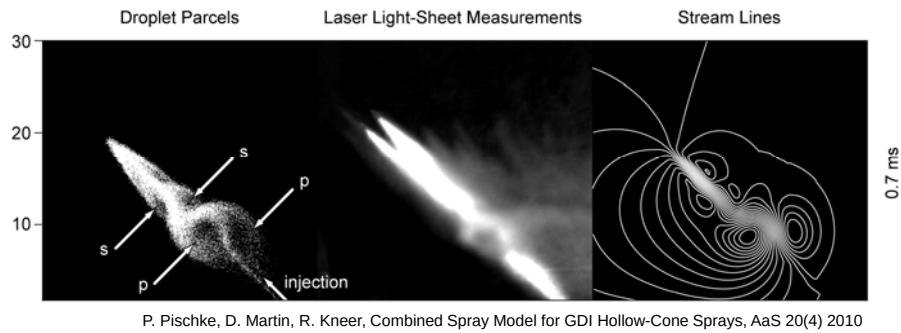
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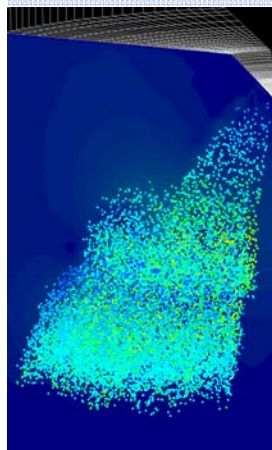
Collision and Coalescence Model Modified Four-Regime Model



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Conclusions



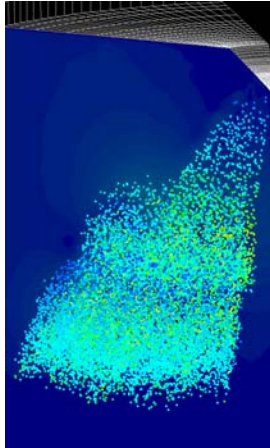
- The models implemented have significantly improved the accuracy of the simulation
- Open model structures allow for in-depth investigations of all modelling aspects
- Fluent offers great extensibility by User Defined Functions (UDFs)



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Thanks for Your Attention



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