

Mathematical models involved in phase transitions of snow - water - vapor

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Mathematical modeling and simulation are tools of technology development

- Understanding of technological processes
- Optimization of technological processes
- Reduction of the number of prototypes

Examples:

Car design: drag reduction, noise reduction,
optimization of combustion

Semiconductor chips: minituarizatziion, power reduction,
cooling requirements, new functionalities

Diaper production: quality control

Microscopic vs. Macroscopic Models

Example: the air in this room

Microscopic description: particles, 3D billiards

Problem: on the order of

10.000.000.000.000.000.000.000 molecules



Macroscopic description: averaged quantities

like density, pressure, temperature,

mean velocity → Navier-Stokes equations

Microscopic modeling of the dendrite generator

Unstructured (vapor, ice) **and structured** (droplets, snow, graupel) **particles.**

Structured particles vary in size and shape.

Transitions between particle types by collisions and phase changes

Examples: **deposition** of vapor on ice, snow, graupel
collection of droplets by snow, graupel
evaporation/condensation

Heat balance: heating/cooling by phase transitions

Macroscopic modeling of the dendrite generator

- Description by (a small number of) averaged quantities such as densities of particle types
- Parametrization of all possible shapes of snow flakes and of size distributions (supported by experimental results)
- Coupling with the air flow

Goals and Outlook

- Derivation of a minimal model suitable for simulations (starting from models for natural clouds)
- Include an account for different shapes of snow flakes (i.e. different snow quality), supported by experiments
- Reasonable quantitative match between predictions and measurements for present forms of the DG
- Contribute to geometry optimization and snow quality control