Contribution ID: **23** Type: **Talk**

Snowflake growth in supersaturated atmosphere using a three-dimensional phase-field model

Monday 8 January 2018 14:50 (20 minutes)

Simulating ice crystal growth is a major issue for meteorology and aircraft safety [1]. Notwithstanding, very few models currently succeed in reproducing the diversity of snowflake forms in three dimensions, and the link between model parameters and thermodynamic quantities is far from being established. Here, we present a 3D modified phase field model that describes the subtlety of the ice-vapor phase transition leading to snow crystal growth, through anisotropic water molecules attachment and condensation, surface diffusion, and strongly anisotropic surface tension [2]. We demonstrate that this model is capable of reproducing properly the morphology and growth kinetics of snowflakes in supersaturated atmosphere. Aside from that, we show that the growth dynamics of snow crystals simulated thereby, satisfies the selection theory, consistently with previous experimental observations [3]. Finally, we present a morphology diagram in experimentally accessible units, that links the manifold of simulated snowflake shapes to atmospheric parameters.

[1] BRUNEL, M., DEMANGE, G., FROMAGER, M., et al. Instrumentation for ice crystal characterization in laboratory using interferometric out-of-focus imaging. Review of Scientific Instruments, 2017, vol. 88, p. 083108.

[2] DEMANGE, G., ZAPOLSKY, H., PATTE, R., et al. A phase field model for snow crystal growth in three dimensions. NPJ Computational Materials, 2017, vol. 3, p. 1.

[3] DEMANGE, G., ZAPOLSKY, H., PATTE, R., et al. Growth kinetics and morphology of snowflakes in supersaturated atmosphere using a three-dimensional phase-field model. Physical Review E, 2017, vol. 96, p. 022803.

Significance statement

1/ New numerical model:
-3D phase field model for highly anisotropic crystal growth with sixfold symmetry.
-Synergistic effect of kinetic and surface tension effects
2/ Encouraging results
-Selection theory for snowflake growth
-Quantitative link with experiments

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Track Classification: Ice Crystal Growth