MODELING OF PATTERN FORMATION DURING BRINE CHANNEL FORMATION

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Macro-scale

$$\varphi(\eta) = \bigcup_{\alpha}^{\kappa} (\varphi(\eta))^{\alpha} = \bigcup_{\alpha}^{\kappa} \left(\bigcup_{\beta(\sigma)}^{\nu} (\varphi(\eta))^{\alpha\beta(\sigma)} \right)$$

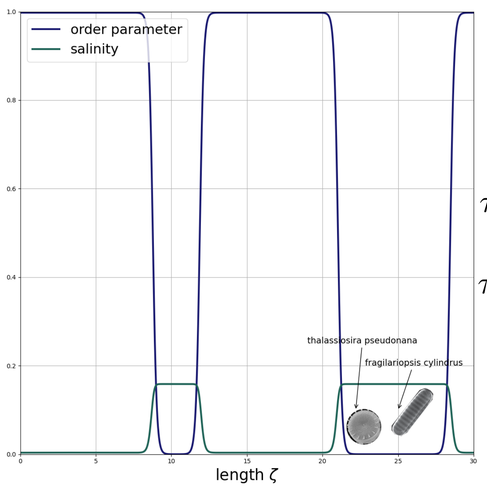
R. Pathak et al.[1]

⇑

Coupling between macroscopic and microscopic order parameter $\varphi \Leftarrow \eta$ and macroscopic and microscopic salinity $\beta \Leftarrow \sigma$

⇑

Micro-scale

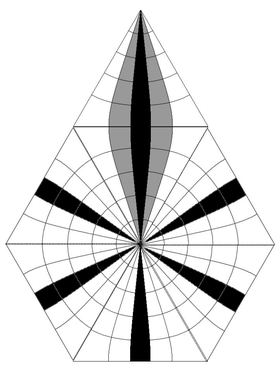


$$\tau_0 \frac{\partial \eta}{\partial \tau} = -a^4 \eta \left(\eta - \frac{1}{4a} \left(3 - \sqrt{1 + 16m - 8\sigma} \right) \right) \left(\eta - \frac{1}{4a} \left(3 + \sqrt{1 + 16m - 8\sigma} \right) \right) + \frac{\partial}{\partial \zeta} \varepsilon^2 \frac{\partial}{\partial \zeta} \eta$$

$$\tau_0 \frac{\partial \sigma}{\partial \tau} = \frac{\partial}{\partial \zeta} \varepsilon^2 \frac{\partial}{\partial \zeta} \left(\frac{1}{4} a^2 \eta^2 + \gamma \sigma \right)$$

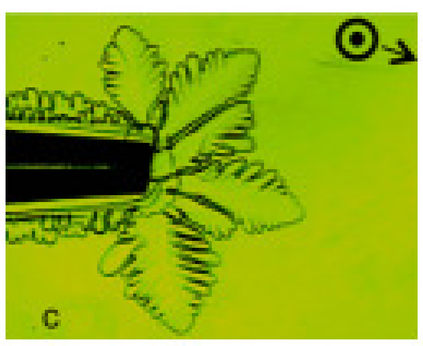
Scaled version of Thoms et al.[2] resp. Morawetz et al.[3]

Anisotropic enhancement



Schwarz-Christoffel transformation

Phase field simulation



Different morphologies of ice single crystals observed by bright-field microscopy without AFPs (left) and with right μM (right)[4]

References

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2. S. Thoms, B. Kutschan, K. Morawetz, (2014). "Phase-field theory of brine entrapment in sea ice: Short-time frozen microstructures". arXiv preprint arXiv:1405.0304.

3. K. Morawetz, S. Thoms, B. Kutschan, "Formation of brine channels in sea ice", Eur. Phys. J. E. 40: 25 (2017).

4. M. Bayer-Giraldi, Gen Sazaki, Ken Nagashima, Sepp Kipfstuhl, Dmitry A. Vorontsow, and Yoshinori Furukawa. "Growth suppression of ice crystal basal face in the presence of a moderate ice-binding protein does not confer hyperactivity", Proceedings of the National Academy of Sciences of the United States of America, 115(29) (2018). doi: https://doi.org/10.1073/pnas.1807461115.

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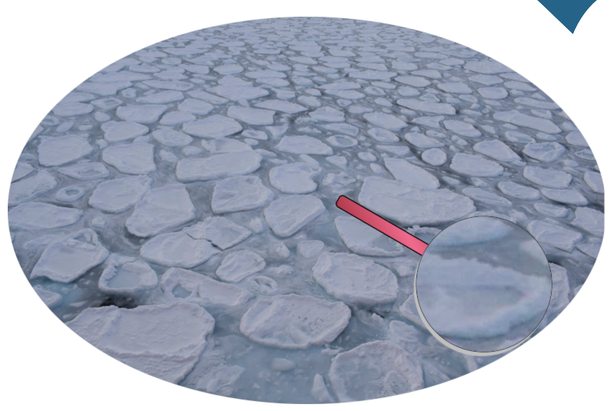
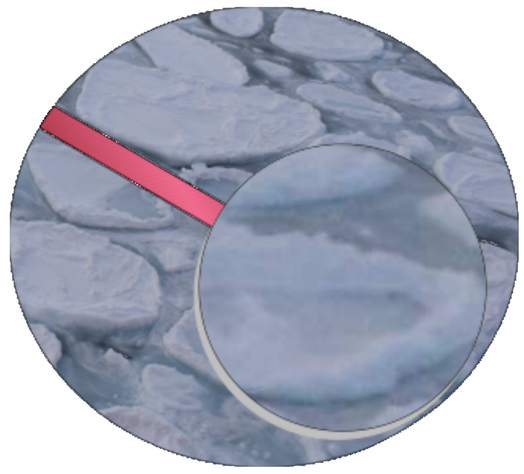
Universität Stuttgart

DFG-SCHWERPUNKTPROGRAMM 1158 ANTARKTIS FORSCHUNG mit vergleichenden Untersuchungen in arktischen Eisgebieten

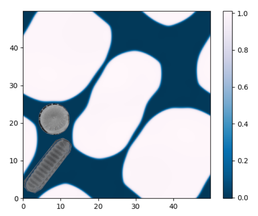
Pancake ice



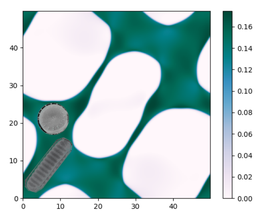
Freezing process simulation



Brine channels



Order parameter η



Salinity σ

Nucleation process