

Pattern formation induced by propagating precipitation fronts¹

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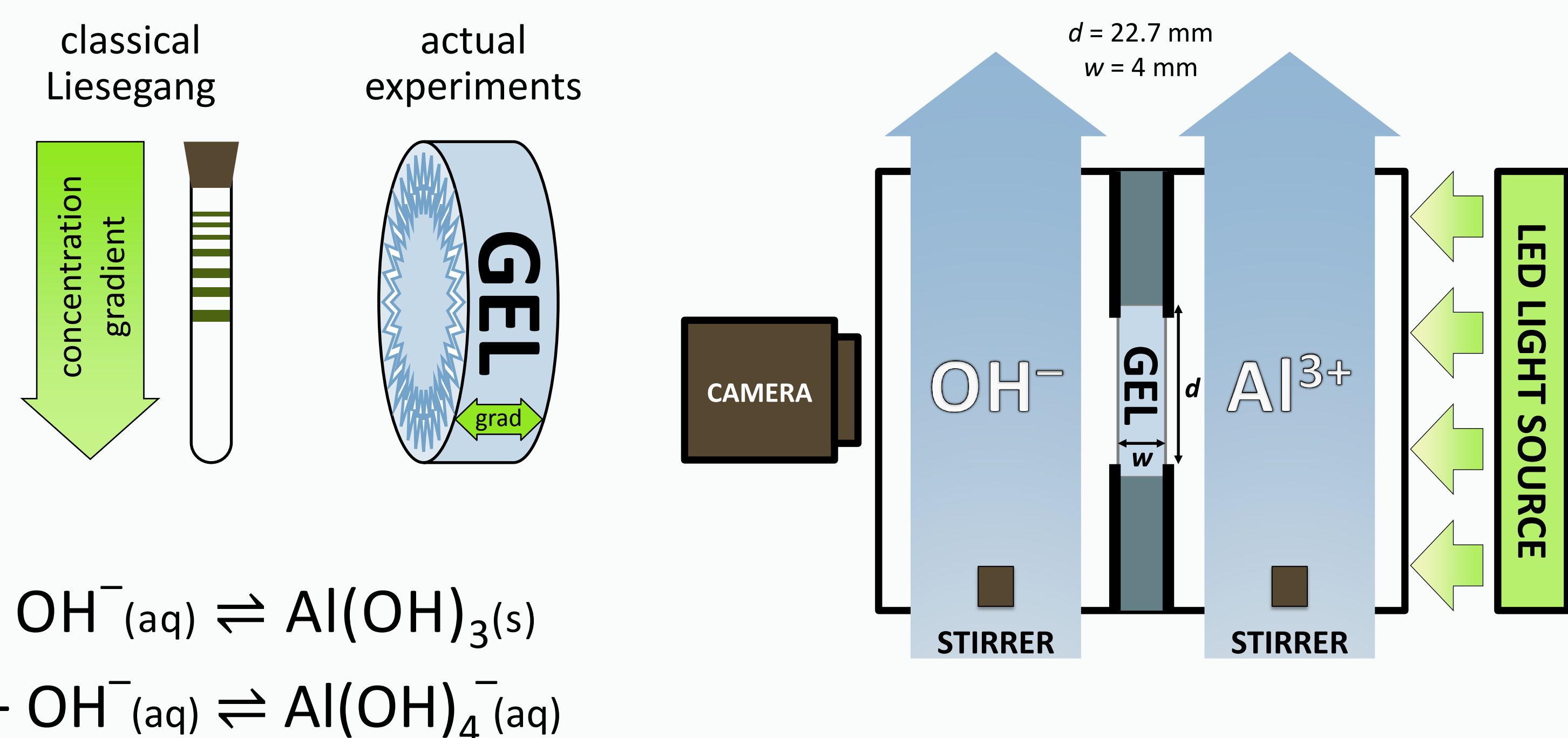
Introduction

Precipitation processes are essential in many natural systems, especially in biomineralization and in geological pattern formation. The basic mode of pattern formation in solidification processes is the growth of cellular and dendritic structures due to the Mullins–Sekerka instability that appears in supersaturated systems and that amplifies shape perturbations of the propagating solidification front. The interplay of diffusion and chemical reactions can spontaneously lead to the formation of various spatial structures.

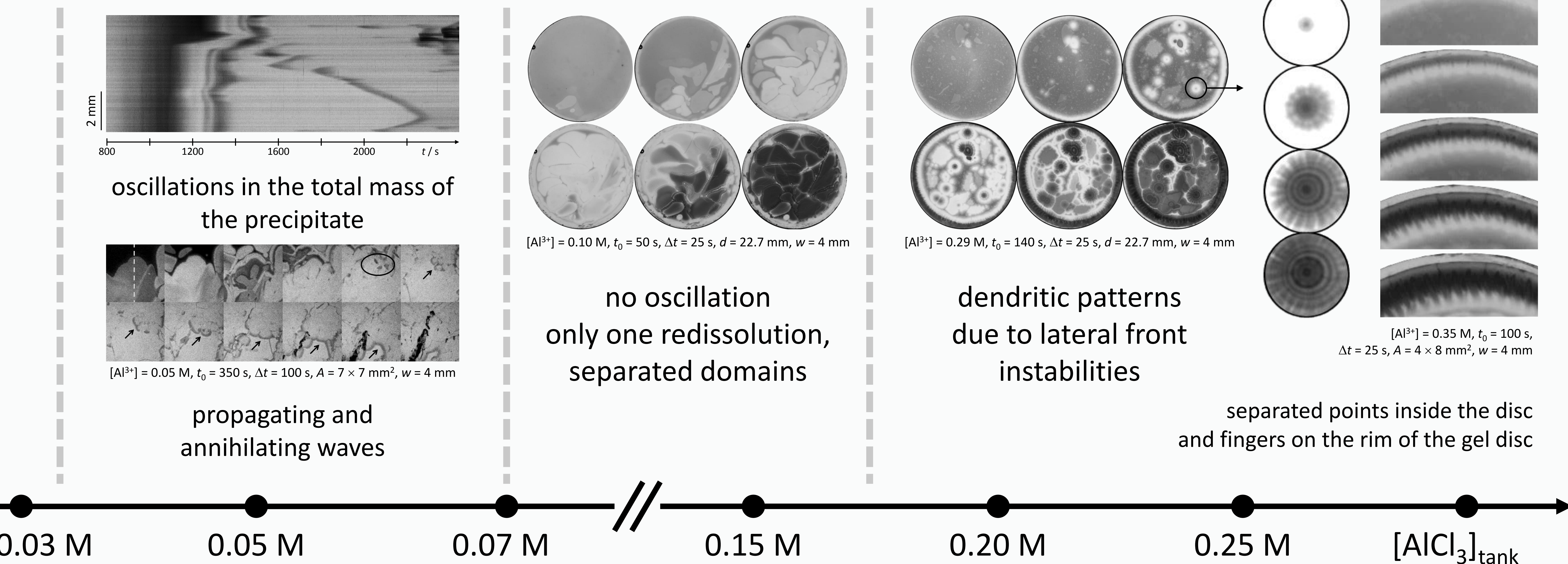
Experimental setup

Contrary to the classical Liesegang rings, the precipitation pattern in my experiments has been observed:

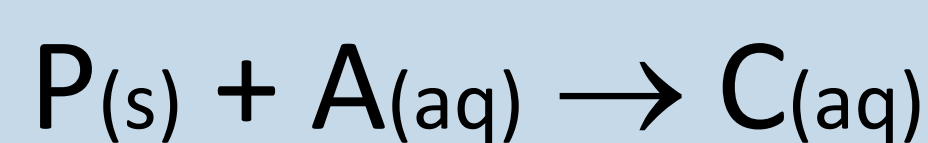
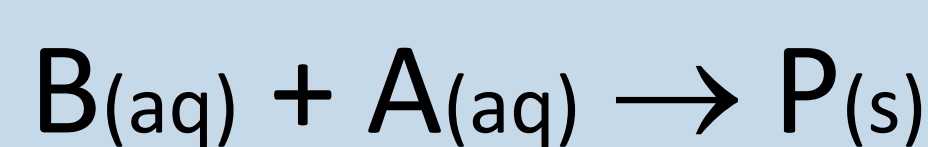
- perpendicular to the diffusion flux,
- at the meeting of two diffusion fronts,
- the gel was empty at the beginning.



Experimental results



Numerical model²

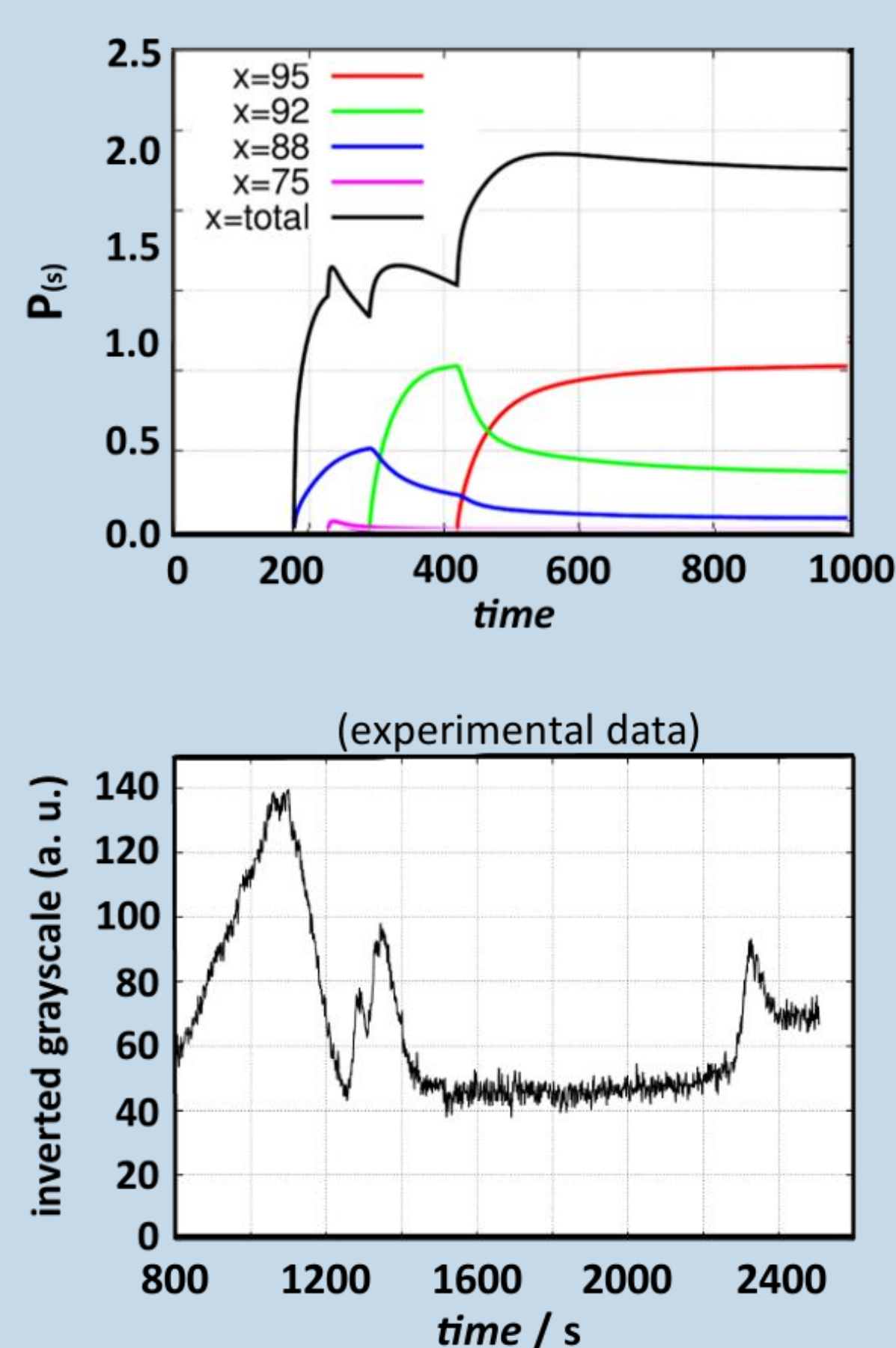


$$\partial_t a = D_a \partial_x^2 a - f(a, b, p) - k_1 p a$$

$$\partial_t b = D_b \partial_x^2 b - f(a, b, p)$$

$$\partial_t p = f(a, b, p) - k_1 p a$$

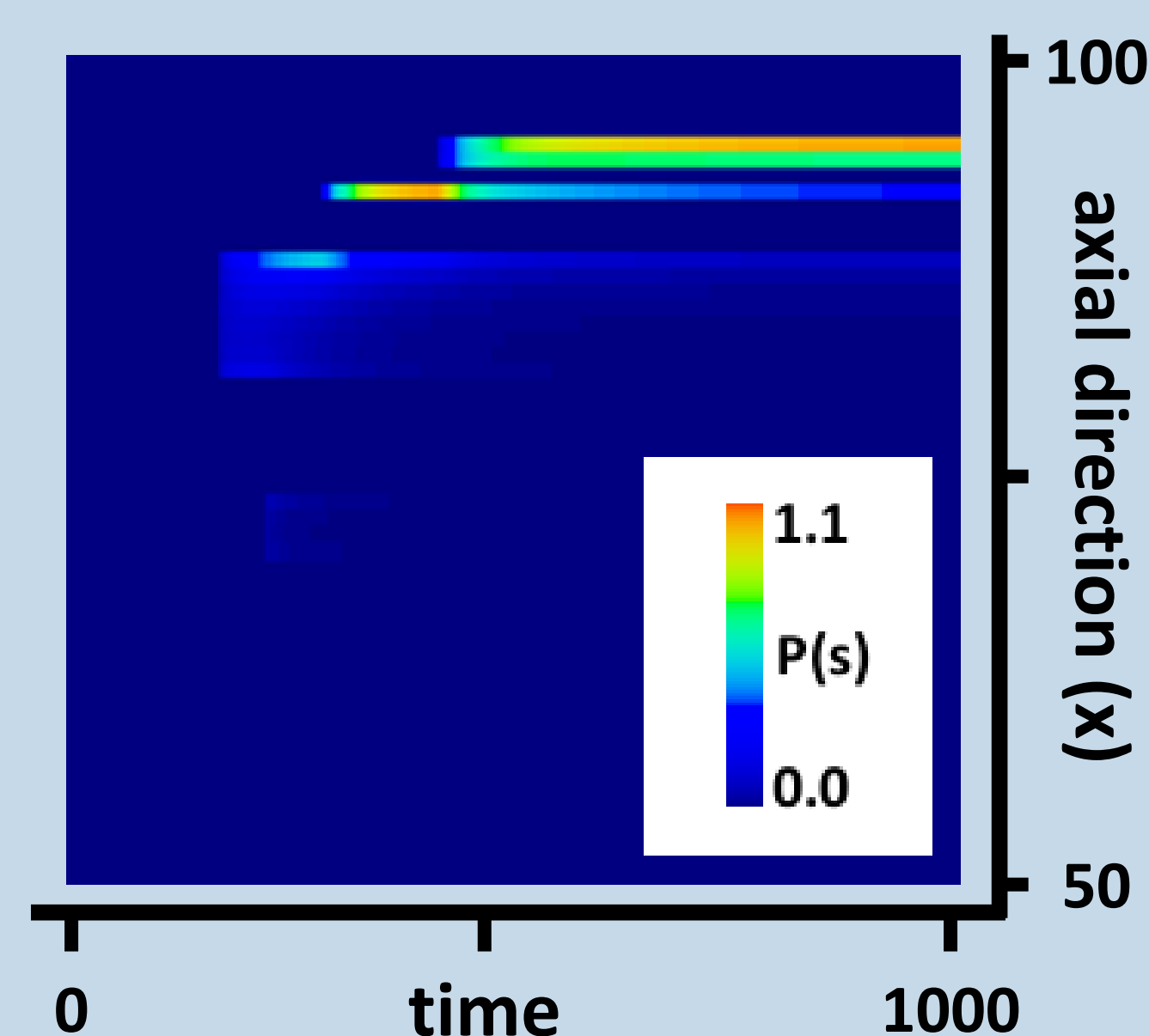
$$\partial_t c = D_c \partial_x^2 c + k_1 p a$$



1D simulations with a four-variable prenucleation type precipitation-redissolution model qualitatively reproduce the oscillations in the total mass of the precipitate and point out the stratified three-dimensional structure of the precipitate. Dirichlet boundary conditions were applied, according to the presence of the continuously refilled tanks at the opposite sides of the gel.

Conclusion

The interplay of diffusion, precipitation formation and complex formation in an open system results in three different dynamical scenarios depending on the aluminium-ion concentration. In contrast to these lateral patterns the oscillation in the total mass of the precipitate was simulated with a one-dimension model.



Experimental conditions

The gel was made of 1 w/w% agarose. V_{tank} = 12.56 ml and the tanks were filled with the solutions at a flow rate of 4.8 ml/min and then the flow rate was set to 0.6 ml/min. [OH⁻]_{tank} = 2.5 M and the AlCl₃ solutions contained [H₂SO₄] = 0.01 M. The recording of the pictures started when the tanks were completely filled. T = 25 °C.

Acknowledgement

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References

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- Lagzi I.; Izsák F. Regular Liesegang patterns and precipitation waves in an open system. *Phys. Chem. Chem. Phys.* **2005**, *7*, 3845–3850.