**Transient nucleus growth in liquid crystals**

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**Motivation**

- In the 1st order isotropic to nematic transition of liquid crystals the radius of a nematic domain grows as $R \propto t^p$, where $n$ has been found² to depend on the undercooling $\Delta T = T - T_C$, where $T_C$ is the coexistence temperature.
- The radius of a nematic domain grows as $R \propto t^{1/2}$ for low undercooling.
- The radius grows as $R \propto t^1$ for high undercooling.
- $n(\Delta T)$ resembles an $S$-curve as a function of $\Delta T$.

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**Latent heat and nucleus growth**

For a first order phase transition the change of phase is accompanied by release or uptake of latent heat. The diffusion of latent heat away from the growing nucleus may explain the $R \propto t^{1/2}$ growth for low undercooling.

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**Radius of the growing nucleus**

Here we show the radius $R(t)$ of a growing nucleus, found by integrating Eqs. (1) and (2) for different values of the undercooling temperature $\Delta T$ in 1D, 2D and 3D. Note that $R(t)$ can be described by a power law only for long times. Also note that for high undercooling the growth rate $R \propto t^1$ and for low undercooling $R \propto t^{1/2}$.

**Exponent of growth**

- By fitting $R \propto t^p$ for different time intervals we study the time dependence of the growth exponent as a function of undercooling.
- The growth exponent follows an $S$-curve that sharpens with time.
- The curvature of the nucleus increases $n$ for low undercooling.
- Effect of this curvature diminishes with time as nucleus size increases.

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**Multiple time / length scales: scaling?**

- For liquid crystals the value of the parameter $p$ in Eq. (1) is very small (10⁻⁶).
- The temperature profile is much wider than the order parameter profile. We would need in the order of 10⁷ grid points and integration over 10⁸ integration steps.
- In one dimension the growth velocity of the nucleus is proportional to the undercooling temperature $u(R(t))$ and $u(R(t))$ scales approximately with the parameter $p$ in 1D.
- By integrating Eqs. (1) and (2) for a wide range of parameters $p$ and rescaling the results, we can estimate $u(R(t))$ for extremely low values of the parameter $p$.
- Our aim is to use this scaling to determine the S-curve of the exponent of growth for parameters and length-scales suitable to describe liquid crystals.

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**Applicability to liquid crystals**

- The undercooling temperature $T_{C,T}$ separating $n=1/2$ and $n=1$ is in the range of liquid crystal (LC) nucleus growth.
- Although the latent heat is quite low in LCs, the thermal diffusivity is also very low.
- Surface tension is very high: S-curve will resemble the 1D simulation result.
- The $p$ parameter is too small for numerical integration. Using a scaling relation may help to determine the applicability more precisely.

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**Conclusions**

- For low undercooling $T_{C,T} > T_{C,T}$ the asymptotic behavior is $R \propto t^{1/2}$, due to the diffusion of latent heat.
- For high undercooling $T_{C,T} > T_{C,T}$, the asymptotic behavior is $R \propto t^1$.
- Because the time at which asymptotic behavior is reached depends on the undercooling, experimentally an $S$-curve is measured. Asymptotic behavior may never be reached because nuclei start to coalesce.

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**References**


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**Graphs and Figures**

- **Graph 1**: S-curve for the growth rate $R(t)$ as a function of the undercooling $\Delta T$.
- **Figure 1**: Experimental determination of growth exponent $n$ as a function of undercooling $\Delta T$.
- **Figure 2**: Theoretically predicted change of order parameter field with the change in the order parameter as the latent heat source.
- **Figure 3**: Exponent of growth as a function of undercooling for 3 time intervals (blue: 10⁴, red: 10⁵, green: asymptotic curve). Some data are depicted in the figure to the left of the figure.