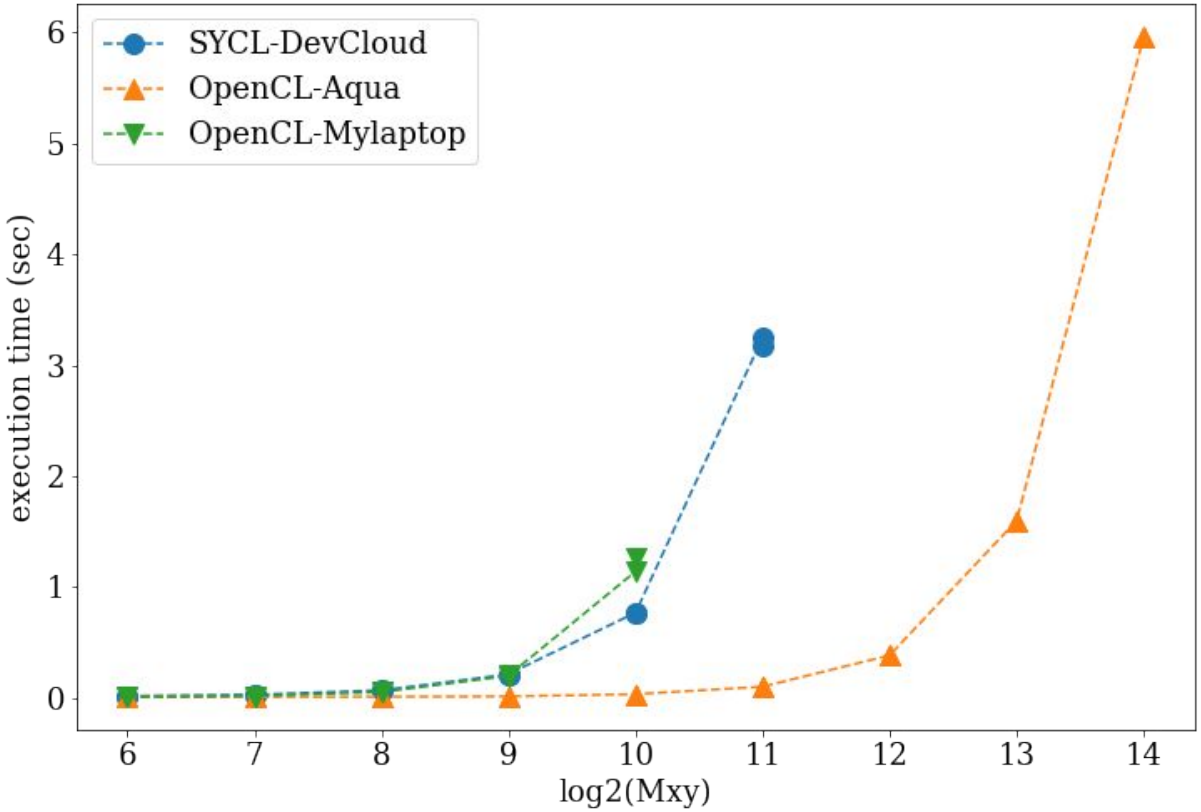
Phase Field with SYCL vs MPI vs OpenCL

Basic Diffusion : CPU vs GPU

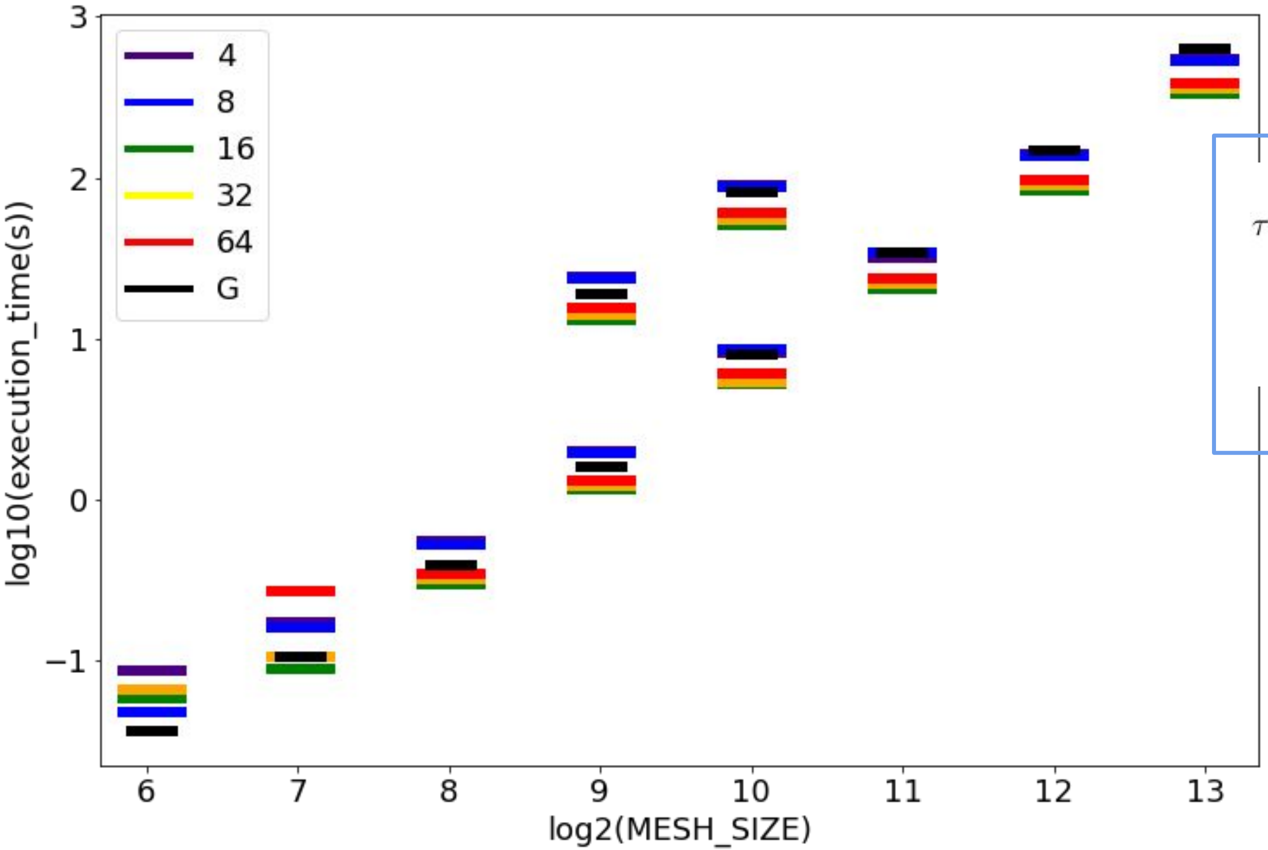


$$\frac{\partial \phi}{\partial t} = D\nabla^2\phi$$

Execution time vs mesh size for Diffusion model run on multiple devices. For 2000 iterations

- NVIDIA CUDA Tesla V100-PCIE-32GB - GPU (IITM aqua cluster)
- Intel(R) Xeon(R) Silver 4110 CPU @ 2.10GHz (DevCloud)
- Intel(R) Core(TM) i5-8250U CPU @ 1.60GHz (My Laptop)

Isotropic Solidification : Local vs Global memory

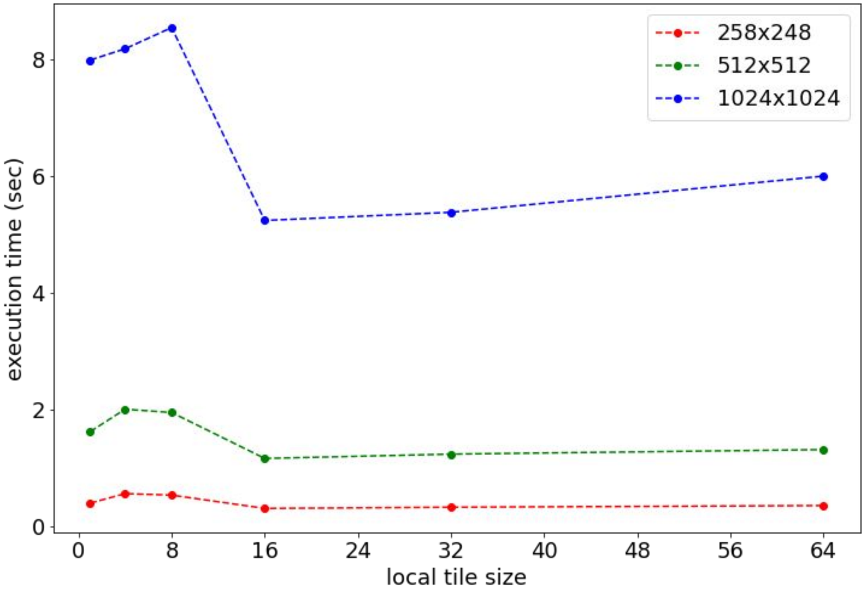


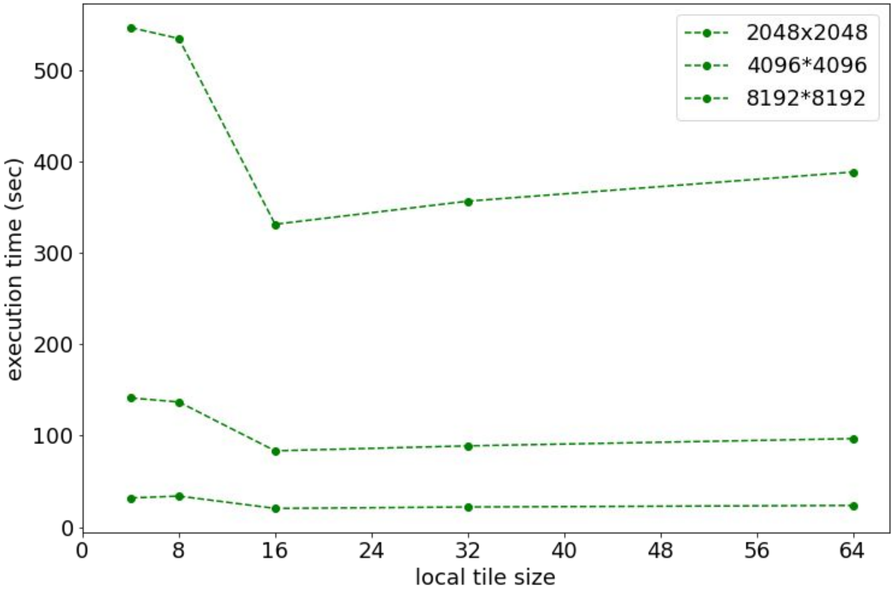
$$\tau \frac{\partial \phi}{\partial t} = \epsilon^2 \nabla^2 \phi + \phi(1-\phi)(\phi - \frac{1}{2} + m)$$

$$\frac{\partial T}{\partial t} = \nabla^2 T + \kappa \frac{\partial \phi}{\partial t}$$

Execution time vs mesh size for KobIso model run on Intel DevCloud (Xenon CPU)

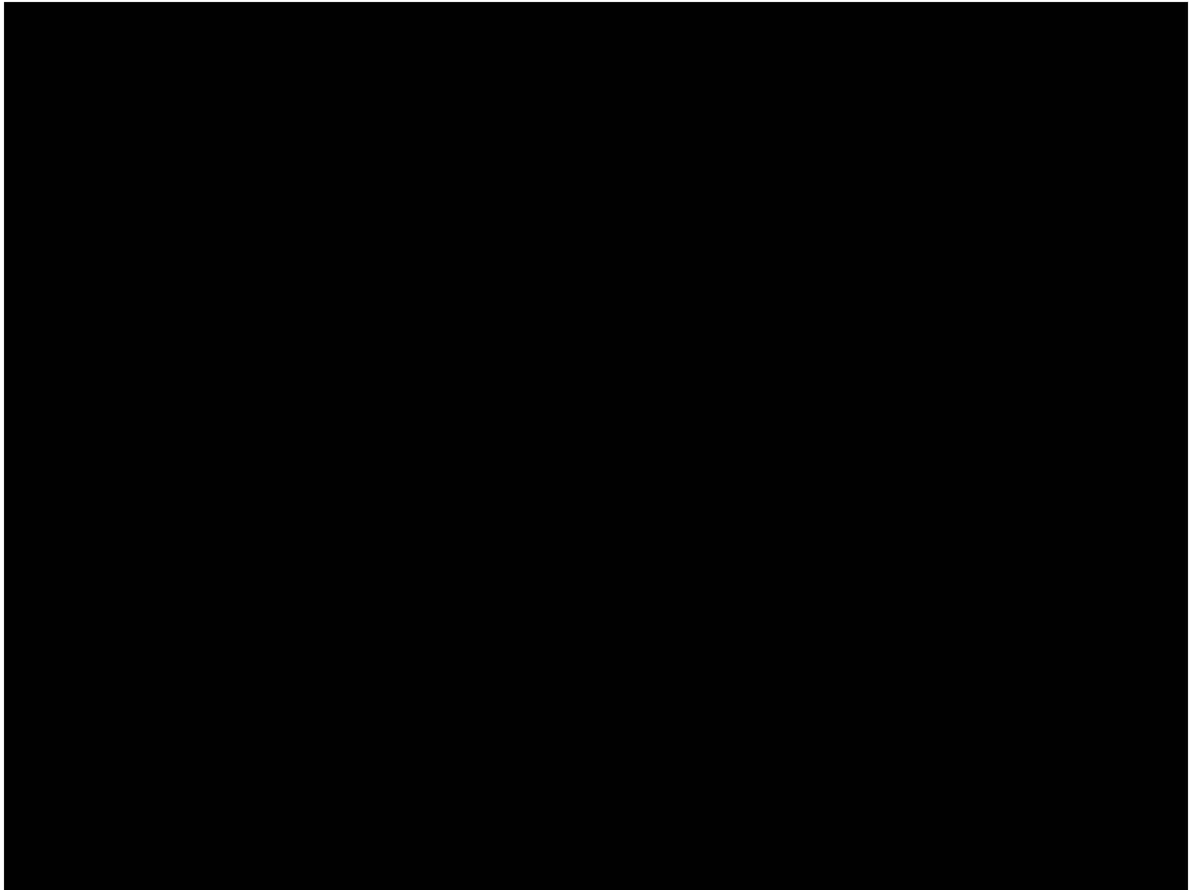
Individual Execution time plots



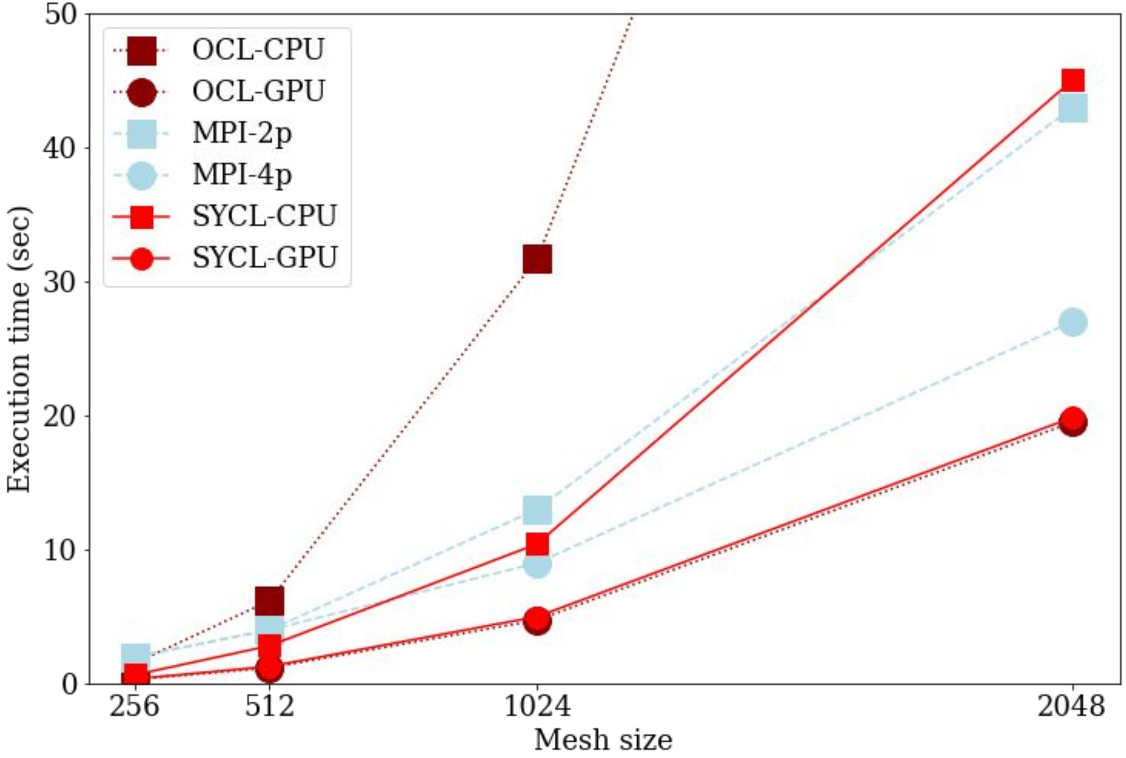


Execution time vs local tile size for KobIso model run in Intel DevCloud (for 2000 iterations)

Isotropic Solidification : Results



Anisotropic Solidification : SYCL vs OpenCL vs MPI



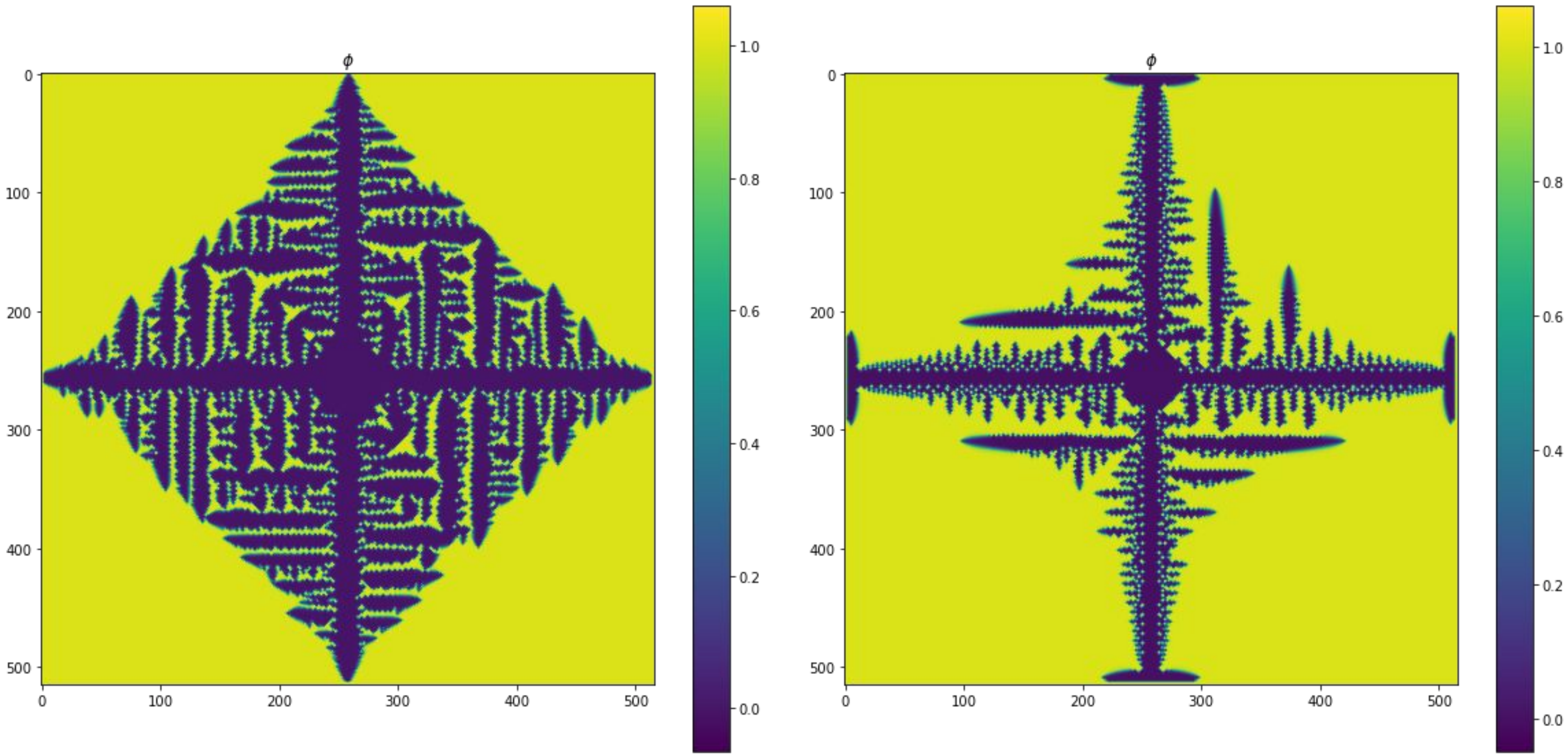
$$\tau \frac{\partial \phi}{\partial t} = \frac{\partial}{\partial y}\left(\epsilon \frac{\partial \epsilon}{\partial \theta}\frac{\partial \phi}{\partial x}\right) - \frac{\partial}{\partial y}\left(\epsilon \frac{\partial \epsilon}{\partial \theta}\frac{\partial \phi}{\partial y}\right)$$

$$+ \nabla.(\epsilon^2 \nabla \phi) + \phi(1-\phi)(\phi - \frac{1}{2} + m)$$

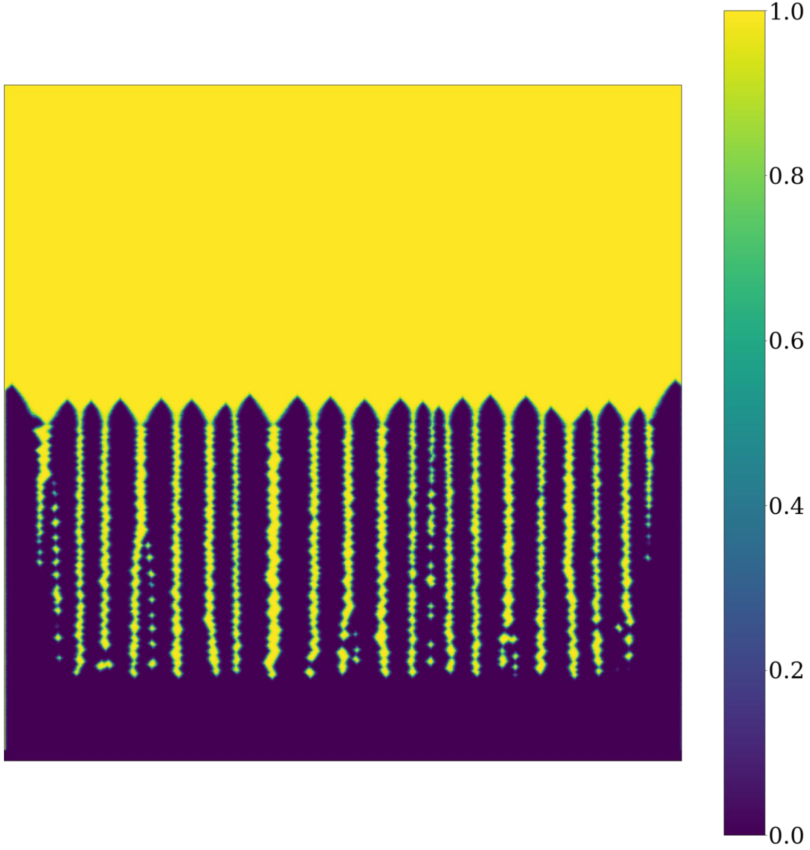
$$\frac{\partial T}{\partial t} = \nabla^2 T + \kappa \frac{\partial \phi}{\partial t}$$

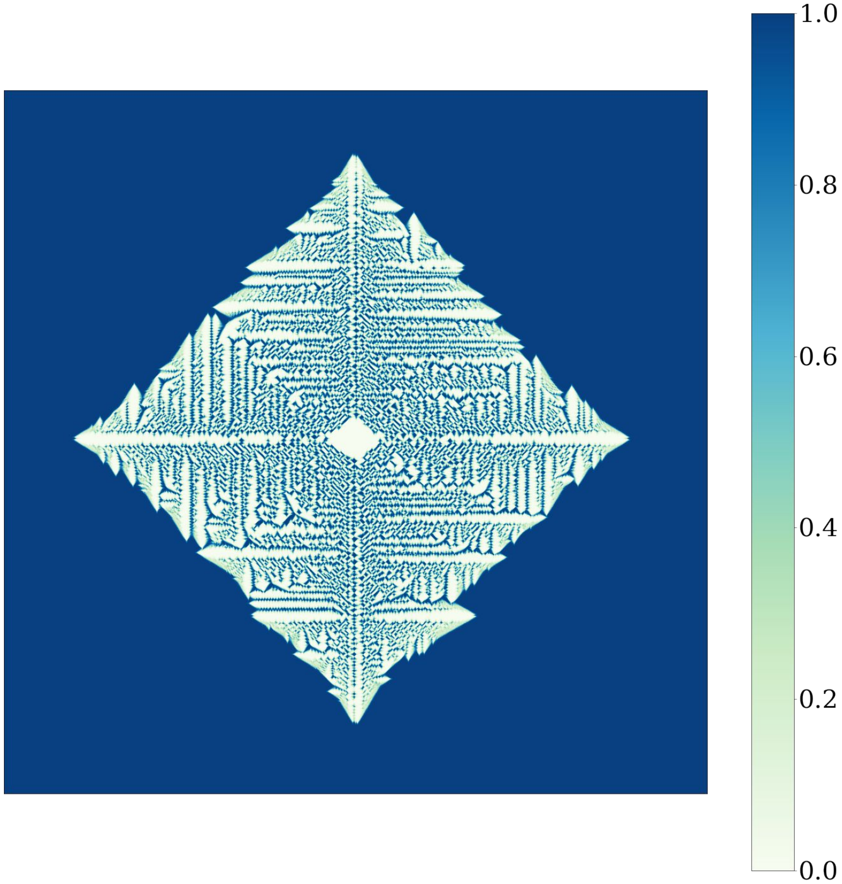
Execution time vs mesh size for KobAniso model run on my laptop (2000 iterations)

Anisotropic Solidification : Results



Anisotropic Solidification : Results





The Kim Kim Suzuki Model

The Mathematical Model

$$\frac{1}{M_\phi}\frac{\partial \phi}{\partial t} = \nabla.(\epsilon_\phi^2 \nabla \phi) + W g'(\phi) + h'(\phi)[f^L(c_L) - f^S(c_S) - (c_L - c_S) f^L_{c_L}(c_L)]$$

$$\frac{\partial c_1}{\partial t} = \nabla.([1 - h_d(\phi)] D^L_{11} \nabla c_{1L}) + \nabla.(\frac{\epsilon_\phi}{\sqrt{2W}}(c_{iL} - c_{iS})\frac{\partial \phi}{\partial t}\frac{\nabla \phi}{|\nabla \phi|})$$

$$\frac{\partial T}{\partial t} = \nabla^2 T + \kappa \frac{\partial \phi}{\partial t}$$

Phys. Rev. E 60, 7186 (1999) - Phase-field model for binary alloys

GE Functions

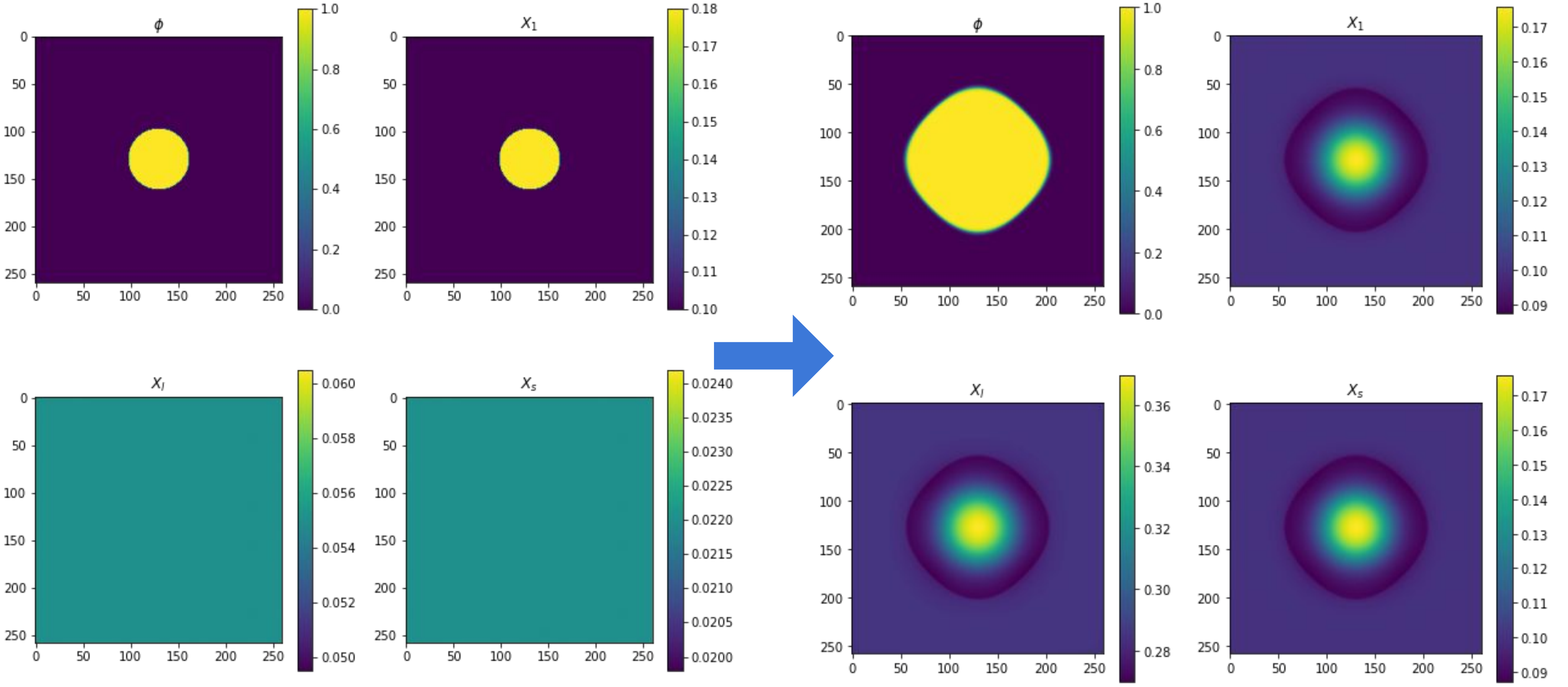
TABLE I. Thermophysical data for dilute Al-Si alloy.

D_S (m^2/s)	1×10^{-12}
D_L (m^2/s)	3×10^{-9}
T_M (K)	933.6
V_m (m^3/mole)	1.06×10^{-5}
σ (J/m^2)	0.093
$f^S V_m$ (J/mole)[a]	$G^0_{\mathrm{Al}}(1-c)+G^0_{\mathrm{Si}}c+RT[c\ \ln c+(1-c)\ln(1-c)]+A^S c(1-c)$
$f^L V_m$ (J/mole)[a]	$RT[c\ \ln c+(1-c)\ln(1-c)]+c(1-c)[A^L+B^L(1-2c)+C^L(1-6c+6c^2)]$
G^0_{Al} (J/mole)[a]	$-10792+11.56T$
G^0_{Si} (J/mole)[a]	$12.12T$
A^S (J/mole)[a]	$-200-7.594T$
A^L (J/mole)[a]	$-10695.4-1.823T$
B^L (J/mole)[a]	$-4274.5-3.044T$
C^L (J/mole)[a]	$670.7-0.460T$
c^e_S	0.006387 (at 870 K)
c^e_L	0.07919 (at 870 K)
k^e	0.0807 (at 870 K)
m^e (K)	939.0 (at 870 K)

[a]Data from Ref. [27].

Phys. Rev. E 58, 3316 (1998) - Interfacial compositions of solid and liquid in a phase-field model with finite interface thickness for isothermal solidification in binary alloys

Preliminary Results



The code