Advancing Front of Solidification [pln38]

Consider a flat portion of solid-liquid interface during the freezing process.

Front of solid phase advances as molecules in liquid phase are being immobilized and incorporated into crystal structure.

Immobilization and binding entail release of energy (latent heat) at interface.

Continued freezing depends on transport of latent heat away from interface into liquid.

Transport of latent heat is dominated by conduction (thermal diffusion).

Heat flux is proportional to temperature gradient (Fourier's law).

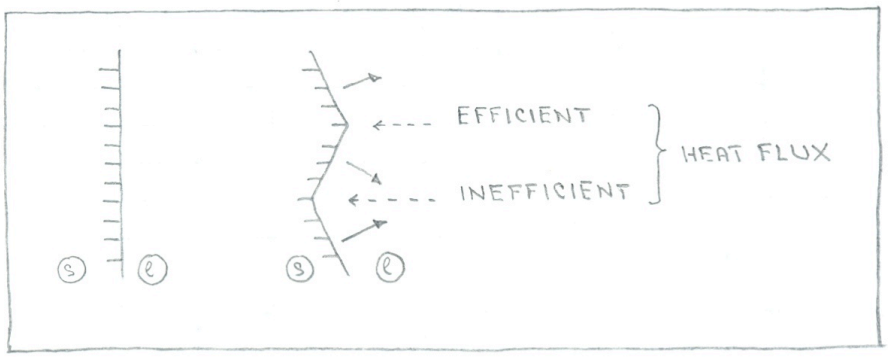
Local deviations from flat interface produce regions where temperature gradient is suppressed and regions where it is enhanced.

In the former regions the heat transport is slowed down, in the latter regions it is accelerated.

Positive feedback renders flat surface unstable against random structures of growing amplitude.

Dominant counteracting force: interfacial tension, favoring a flat interface.

Competing tendencies in balance: profile with a characteristic wavelength.



[extracted in part from Jones 2002]