Morpho-Hydrodynamical Instabilities in Directional Solidification: Transient Instabilities

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Wavelength selection for dendritic and cellular patterns in directional solidification is known to
be a history-dependent process[1,2]. The perturbations to which the system might be
exposed could be important to determine the final wavelength. This wavelength
has important implications in the final physical properties of an alloy.
One of the perturbations that might be impossible to overcome in
realistic experiments is the flow on the molten phase. This flow could be imposed or,
as the case we consider here, be due to convection.
Even if in the steady state there is no convection, it might well be that during the transient
the fluid has been hydrodynamically unstable, which could imply a different final wavelength,
since solute might have been redistributed according to the convection cells.
We present here results concerning the coupling between solutal convection
and morphological instability for a binary alloy. We have undertaken a time-dependent
linear stability analysis of the whole system during the transient. This coupling has been found to be,
for the steady state and for realistic parameters[3] extremely weak in the steady state,
particularly in the influence of convection on morphology, but nevertheless this could not be valid at
all during the transient.
We have performed, using the Warren-Langer approximation[2] for the evolution of a flat
interface during the transient, a time dependent linear stability analysis for the coupled equations of
solute diffusion and flow evolution. We present a discussion on the effect of flow in the
stability of the front during the transient.

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