# Oscillatory instabilities in directional solidification with solutal convection. Transient regime.

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Directional solidification of alloys has long been an archetypical model system in pattern formation, and is also of capital importance in many practical and industrial applications, ranging from the casting of turbine blades to the production of solar cells. The precise control of these processes as well as the prediction of the resulting microstructure, on which the final material properties depend largely, constitute a very active field of research.

In this context, it is well-known that in the controlled setup of directional solidification, experiments give rich and interesting dynamics. In particular, for determined values of the solidification rate a flat interface will develop first a pattern of cells that will evolve into dendrites, very intricate branching structures[1].

Understanding the development of such structures and in particular predicting their spacing in the solidification front is also of importance for the practical applications, and has received much attention in the past. It has been found that in fact this spacing depends on the history of the dendrite, in particular on the transient regime[2].

In this work we focus on the effects of convection on directional solidification processes. It is well-known that convection is one of the main effects perturbing the growth conditions of a solidifying interface, and hence it could be of importance in the transient stages of solidification, even in the cases where it has little or no effect in the steady state growth.

In the particular setup of directional solidification of an alloy, even with an stabilizing thermal gradient, convection can be induced by gradients in concentration, and in some cases cannot be avoided. We have studied its effects on the planar front of solidification in transient stages when coupled with the morphological instability.

We present here a complete theoretical study of the instability of the planar interface for the coupled system in the linear regime during the transient of a typical directional solidification experiment. We have studied it as a function of the diverse control parameters, and give the first unstable wavelength during the transient, with particular attention to the advent of purely transient instabilities.

As an additional result, we have found oscillatory instabilities, which had been predicted[3] for steady-state solidification, and unsuccessfully sought experimentally[4]. We give insights on the range of parameters on which these oscillations take place and study their appearance in transient stages of solidification.

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