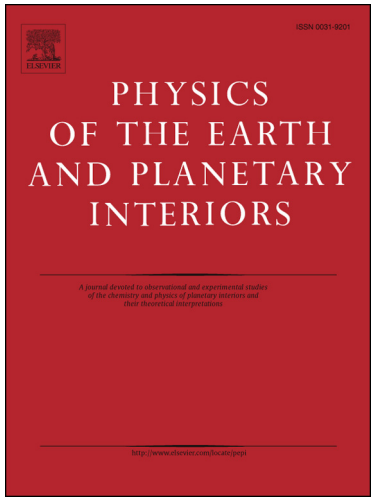

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Global conservation model for a mushy region over a moving substrate

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Abstract

We study solidification over a cool substrate moving with a relative velocity with respect to the rest of the fluid. A mathematical model based on global conservation of solute is presented. The explicit solutions of the governing equations are found and analysed via the asymptotic methods. The assessment of how the boundary-layer flow influences the physical characteristics of the mushy region is given, together with the discussion of possible connection with the solidification at the inner-core's boundary.

Keywords: Solidification, Binary alloy, Mushy region, Global conservation, Boundary-layer flow, Directional solidification

1. Introduction

The solidification of the Earth's inner core can be formulated as a spherical, moving-boundary problem (Buffett et al. 1992, 1996). The liquid outer core can be considered as a binary alloy made from light and heavy components. Analyses of the conditions at the inner/outer core boundary (ICB) suggest that the temperature of the liquid ahead of the boundary is below the local liquidus temperature (Loper and Roberts 1981). Such a condition, known as constitutional supercooling, usually leads to the formation of a so-called mushy region, i.e. a region in which the solid and liquid phases coexist in a thermodynamic equilibrium. From the microscopic point of view, the mushy region has a complicated microstructure made of highly convoluted

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