THE EFFECT OF LOCAL THERMAL NONEQUILIBRIUM ON LAPWOOD-PRATS CONVECTION.

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ABSTRACT

Convection in a uniform porous layer first arises once the Darcy-Rayleigh number exceeds $4\pi^2$, a fact which was first shown by Lapwood (1948) and Horton and Rogers (1945). Later, Prats (1967) extended this work by considering the additional presence of a horizontal pressure gradient which drives the fluid along the layer. He showed that the onset criterion was unchanged but that the phase velocity of the cells is precisely equal to that of the background flow. On the other hand, a different extension was undertaken by Banu and Rees (2002) where the effects of local thermal nonequilibrium were studied, where separate heat transport equations are used for the solid and fluid phases. They found that both the critical Rayleigh number and wavenumber are changed, sometimes very substantially by the presence of local thermal nonequilibrium. The present aim is to determine the manner of combination of these two effects, namely the horizontal pressure gradient and local thermal nonequilibrium.

It is found that there is a competition between the tendency for the cells to move with the background fluid flow and to remain immobile due to the fact that the solid phase is stationary. In many parameter regions there is a smooth transition between these two states, but there are situations in which both the critical wavenumber and the phase velocity of the cells change discontinuously as the background flow velocity increases. This is traced back to the presence of exotically-shaped neutral stability curves.

This paper is an extension of work undertaken by the late Prof Adrian Postelnicu (Postelnicu 2010) and it is dedicated to his memory.

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