Analytical and numerical stability analysis of the flow induced by acoustic streaming in a heated binary fluid layer under weightlessness

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Marie-Catherine Charrier-Mojtabi†, Alain Fontaine† , Abdelkader Mojtabi*

*Université de Toulouse ; INPT, UPS;IMFT (Institut de Mécanique des Fluides de Toulouse);
1, Allée du Professeur Allée Camille Soula, F-31400 Toulouse, France
mojtabi@imft.fr
†PHASE, EA 328, UFR PCA, Université Paul Sabatier,
118 route de Narbonne, 31062, Toulouse cedex, France
cmojtabi@cict.fr

ABSTRACT

Acoustic streaming describes a steady flow generated by an ultrasound wave propagating in a fluid. The ultrasound waves at high frequency are shown to allow a reduction of convection and also to affect the stability of the buoyant convection [1]. The coupling of convection and thermodiffusion leads to species separation independently of the gravity direction [2].

The purpose of this work is to study the influence of acoustic streaming on the species separation which appears in a heated fluid layer in microgravity. A rectangular cavity (height H and length L with L>>H)filled with an incompressible newtonian binary fluid is considered. Two impermeable walls are kept at different and constant temperatures T_{hot} and T_{cold}. A constant radiation pressure is generated in the x direction by an ultrasonic beam of variable dimensionless width ε=d/H placed on the upper part of the wall x=0. (Fig. 1).

The ultrasound field is assumed to be a plane wave traveling in the positive x direction and is characterized by the acoustic streaming control parameter A, defined as: $A = \alpha V_a^2 H^3 / \nu^2$ where α is the spatial attenuation coefficient for ultrasound, V_a the amplitude of the acoustic velocity oscillation and ν the binary fluid cinematic viscosity.

Analytical and numerical techniques are used to study the stability of the unicellular flow obtained. The traversal profiles of the basic unicellular flows are determined analytically. This work showed the possibility of increasing significantly the species separation for an optimal value of the beam width. The optimum separation is obtained for ε=1/2 and the critical value A_c , which characterized the unicellular flow stability loss, is much higher than A_{op} leading to the maximum separation.

REFERENCES

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Figure 1.