On The COMSOL Software Ability On Studying Transition Flows For Low Prandtl Number Fluids

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RESUME

Our study concerned Natural convection of a low Prandtl number electrically conducting fluid (Pr = 0.054) under the influence of either axial or radial magnetic field in a vertical cylindrical annulus has been numerically studied..
The computational results reveal that in shallow cavities the flow and heat transfer are suppressed more effectively by an axial magnetic field, whereas in tall cavities a radial magnetic field is more effective. It is also found that the flow oscillations can be suppressed effectively by imposing an external magnetic field., the present numerical results are shown to be in good agreement with the available benchmark solutions under the limiting conditions.

OBJECTIF

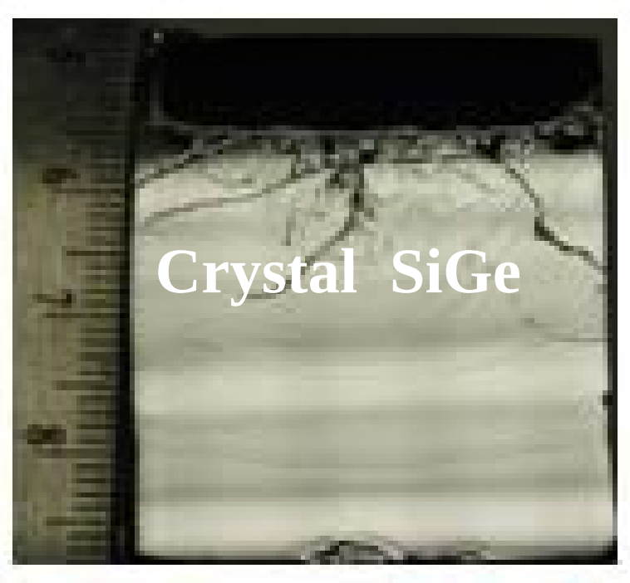
Numerical studie of the effect of the external magnetic field on the thermal convection (Magneto-Convection), in an annular cavity by using **COMSOL** code.

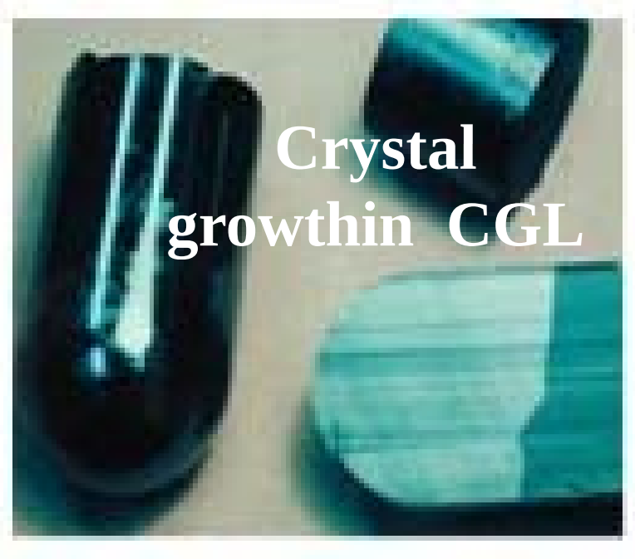
APPLICATIONS MODES

Use of applied magnetic field for:

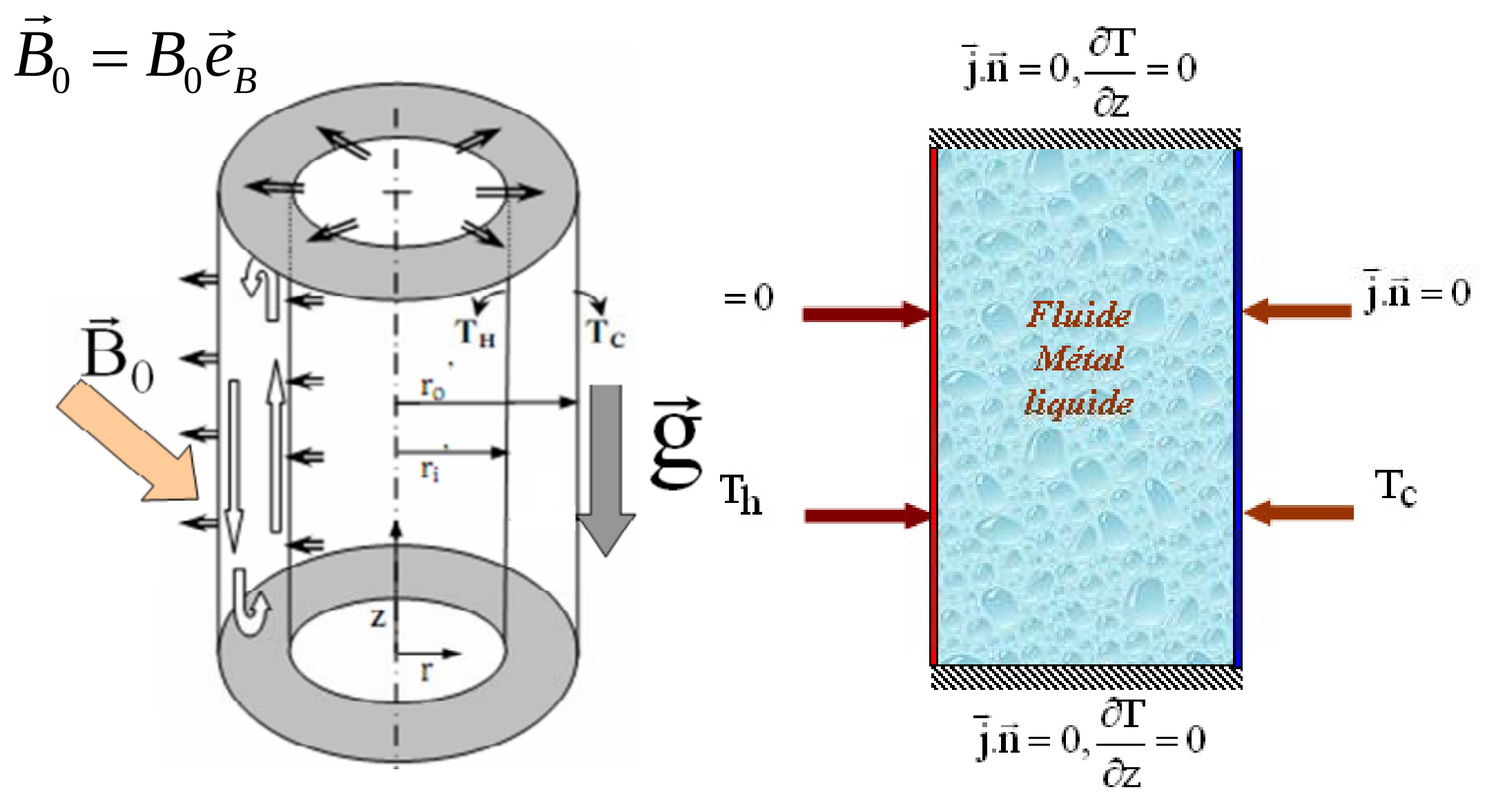
- **Suppressing convection,**
- **Higher growth rates**

- Materials:
  - **Bulk single crystals of GaInAs, SiGe, CdZnTe**
- Applications:
  - **Medical imaging,**
  - **energy conversion,**
  - **high mobility devices,**
  - **solar cells,**


Crystal SiGe


Crystal growthin CGL

Physical Configuration



The fluid is supposed

- **Newtonian.**
- **Incompressible**
- **Obeying of Boussinesq approximation**

Figure1: Geometrical configuration

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Mathematical Model

$$\frac{\partial u}{\partial r}+\frac{u}{r}+\frac{\partial w}{\partial z}=0$$

$$\frac{\partial u}{\partial t}+u\frac{\partial u}{\partial r}+w\frac{\partial u}{\partial z}=-\frac{\partial P}{\partial r}+\Pr\left(\frac{\partial^2 u}{\partial r^2}+\frac{1}{r}\frac{\partial u}{\partial r}+\frac{\partial^2 u}{\partial z^2}-\frac{u}{r^2}\right)+\Pr.Ha^2\left(\vec{j}\wedge\vec{e}_B\right).\vec{u}_r$$

$$\frac{\partial w}{\partial t}+u\frac{\partial w}{\partial r}+w\frac{\partial w}{\partial z}=-\frac{\partial P}{\partial z}+\Pr\left(\frac{\partial^2 w}{\partial r^2}+\frac{1}{r}\frac{\partial w}{\partial r}+\frac{\partial^2 w}{\partial z^2}\right)+\left(\Pr Ra\right)T+\Pr.Ha^2\left(\vec{j}\wedge\vec{e}_B\right).\vec{u}_z$$

$$\vec{j}=(-\vec{\nabla}\phi+\vec{V}\wedge\vec{e}_B)$$

$$\Delta\phi=\vec{\nabla}\left(\vec{V}\wedge\vec{e}_B\right)$$

$$\frac{\partial T}{\partial t}+\left(u\frac{\partial T}{\partial r}+w\frac{\partial T}{\partial z}\right)=\left(\frac{\partial^2 T}{\partial r^2}+\frac{1}{r}\frac{\partial T}{\partial r}+\frac{\partial^2 T}{\partial z^2}\right)$$

RESULTATS

Effect of Axial magnétique Field $\left(\vec{e}_B=\vec{u}_r\right)$

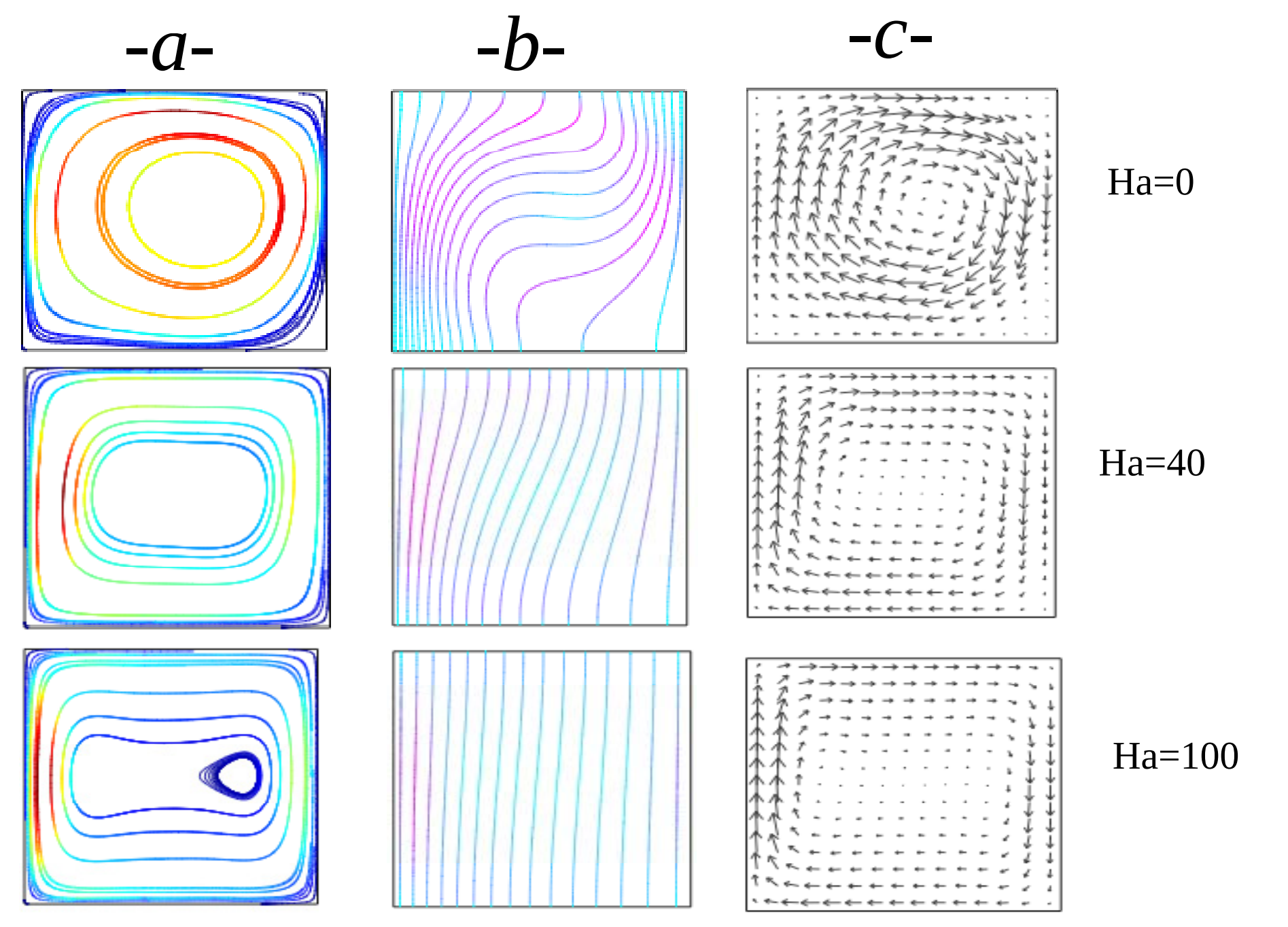

Figure2: (a) the Streamlines, (b) the isotherm , (c) velocity profiles for different values of Hartmann number for, A=1, K=2, Ra=10^4

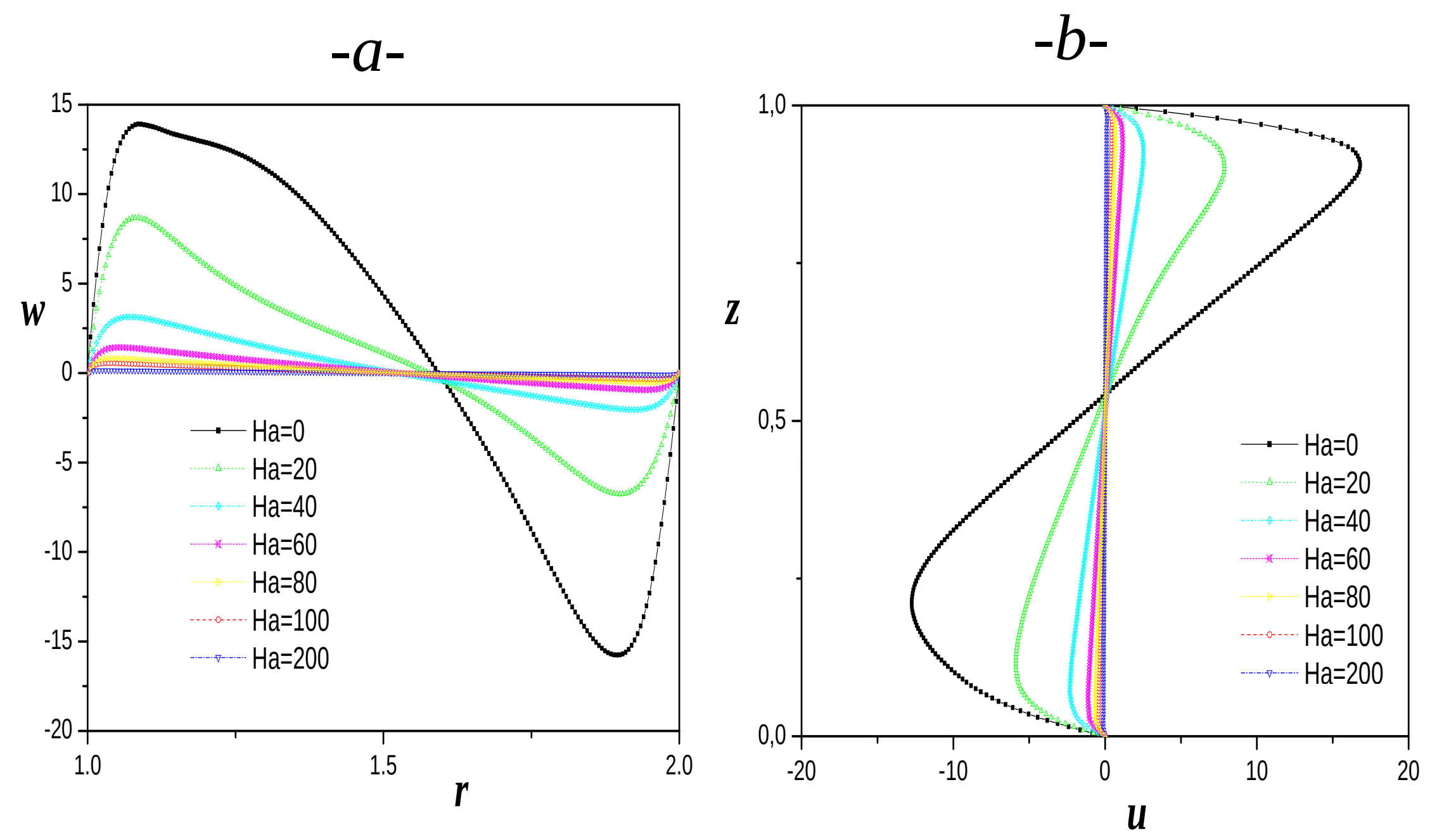

Figure 3: Vertical (a) and horizontal (b) velocity at midheight for, *A = 1, k=2, Ra = 10^4 .*

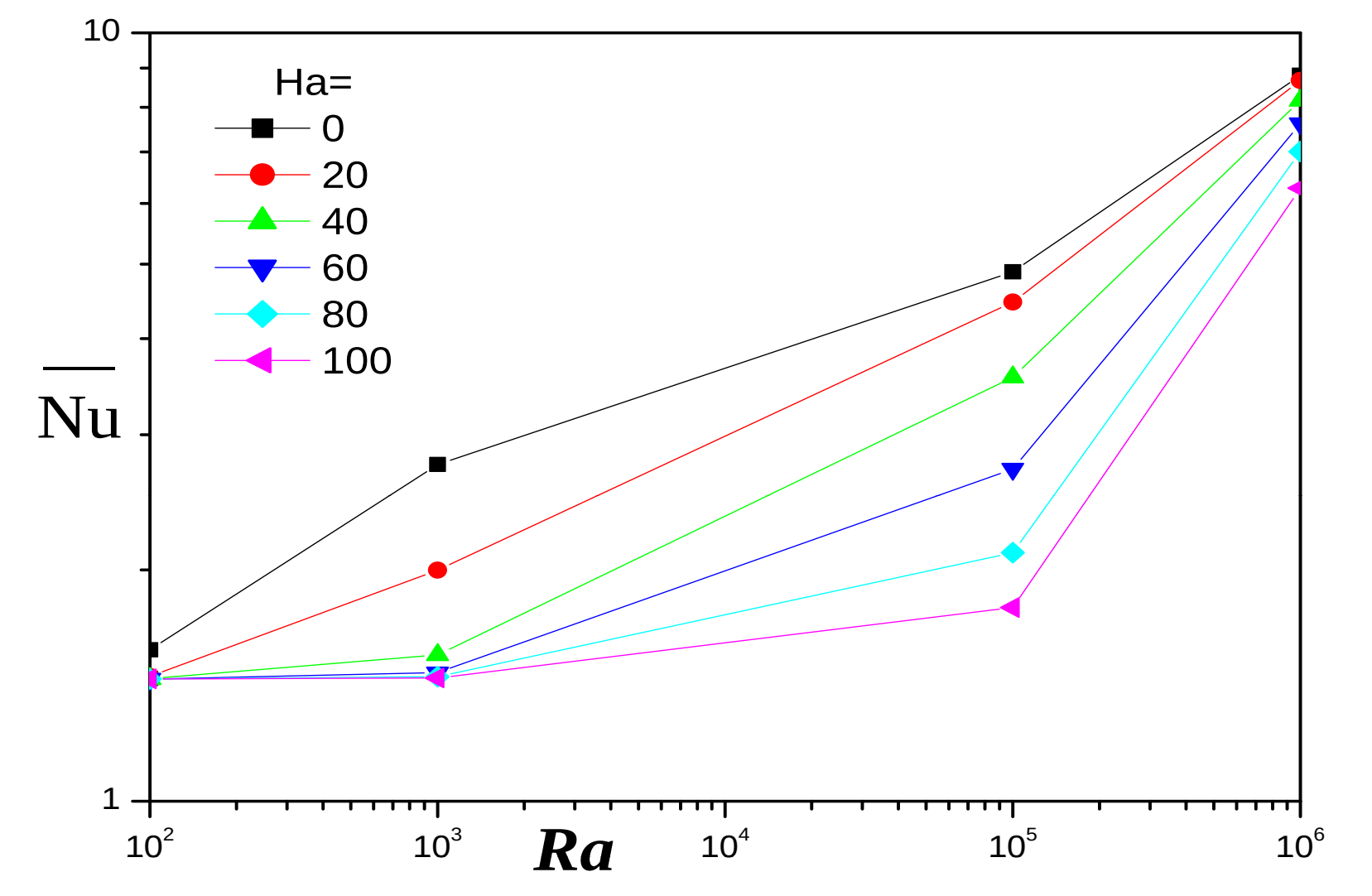

Figure 4: Local heat transfer rate for deferent values of Ha and Ra

radial magnetic field Interpretation

- In the absence of magnetic field (Ha = 0) the flow exhibits a simple circulating pattern rising along the hot wall and descending along the cold wall of the cavity.
- the streams lines are stretched horizontally and the thermal stratification in the core decreases..
- the isotherms are almost parallel and vertical, when the Hartmann number increase..

Comparaison between radial $\left(\vec{e}_B=\vec{u}_r\right)$ and axial $\left(\vec{e}_B=\vec{u}_z\right)$ magnetic field

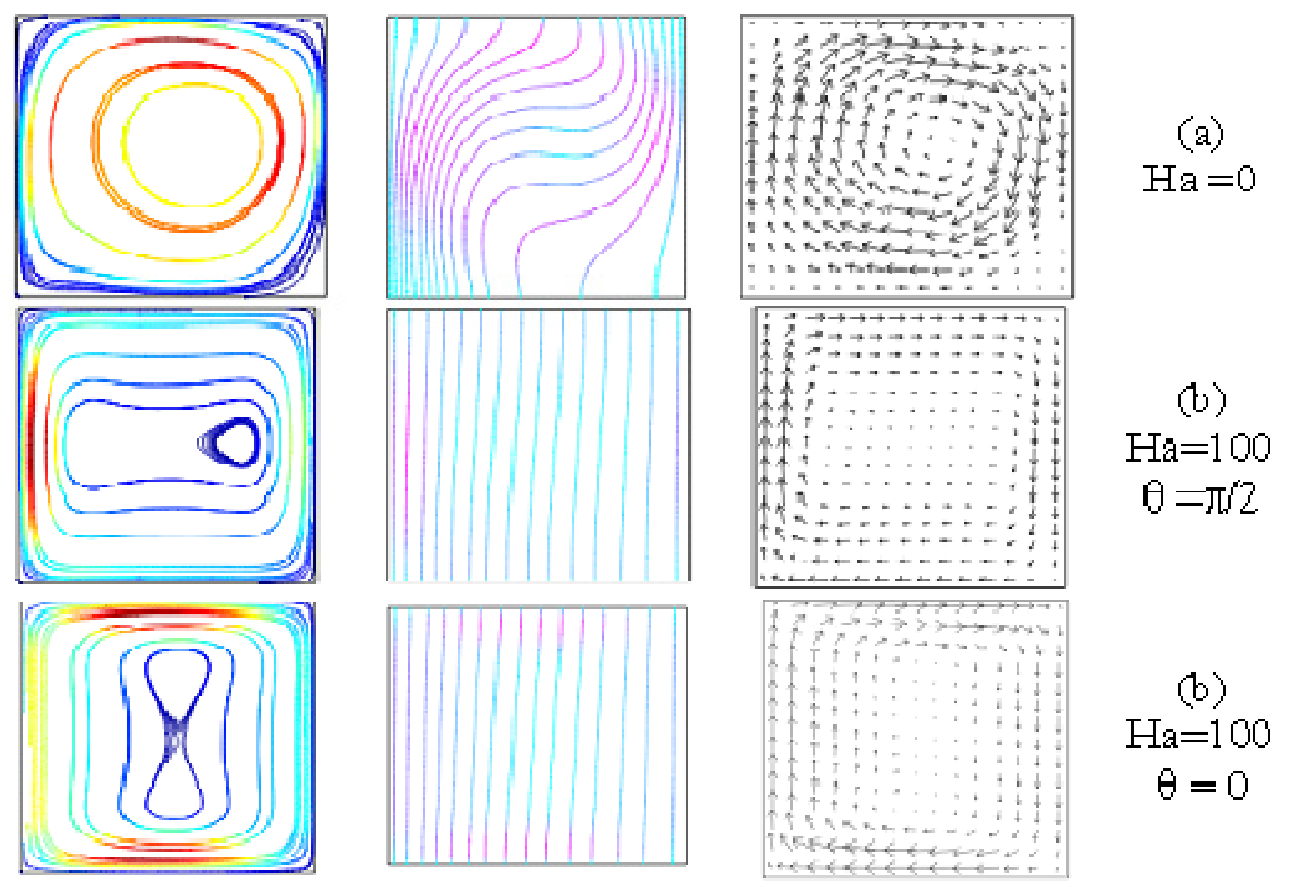

Figure5²: (a) the Streamlines, (b) the isotherm , (c) velocity profiles, A=1, K=2, Ra=10^4

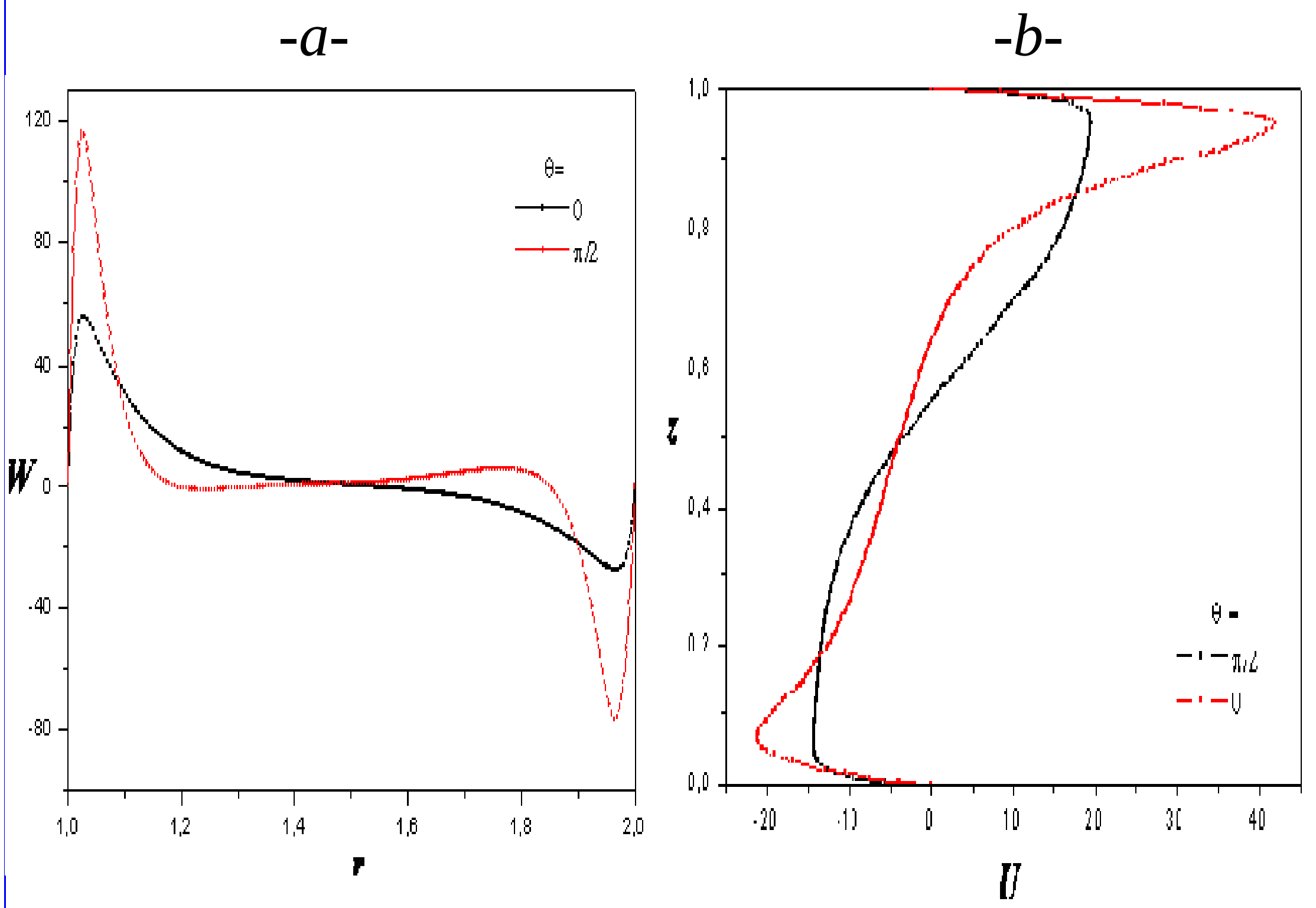

Figure 6: Vertical (a) and horizontal (b) velocity at midheight for, *A = 1, k=2, Ra = 10^6 .*

CONCLUSION

❖The numerical results indicate that the magnetic field suppresses the convective flow and eliminates the flow oscillations.
❖The magnetic field is more effective when it is perpendicular to the direction of the primary flow.
❖ The direction of magnetic field plays an important role in suppressing the convective flows
❖The magnetic field is more effective when it is perpendicular to the direction of the primary flow.
⇨ **This phenomenon has a serious implication on the design of magnetic systems for stabilizing or weakening the convective effects.**