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Stagnation point flow and heat transfer past a permeable stretching/shrinking Riga plate with velocity slip and radiation effects

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IMPORTANCE OF THE STUDY

WHY

- Riga plate
- Suction effect

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- To control motion of the fluids
- To reduce friction and pressure drag

- Magnetic field
- Velocity slip effect

→

- Acting as retarding forces
- To control velocity of the fluid

Radiation

→

- To control heat transfer
- To reduce drag forces

Preventing boundary layer separation and diminishing turbulence production

Applications

Nuclear power plants, various propulsion devices for aircraft, submarines, satellites etc.

PHYSICAL MODEL

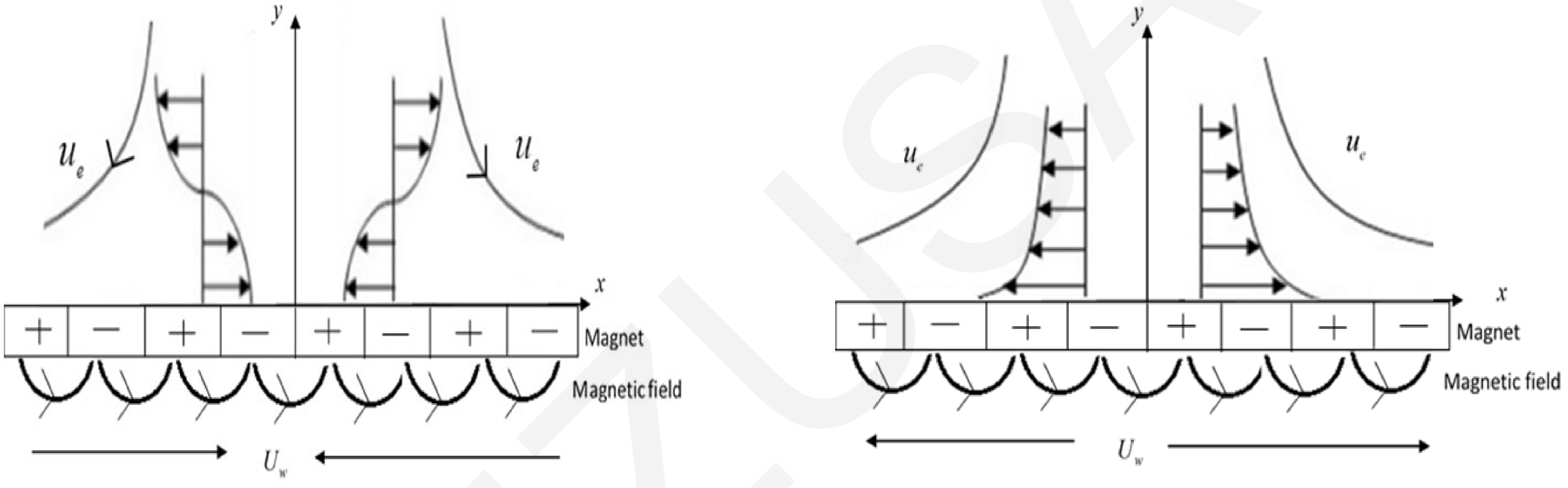

Fig. 1 Physical model of a Riga plate with a) shrinking plate and b) stretching plate

METHODOLOGY

Mathematical Modelling (PDEs)

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Reduce PDEs to ODEs using similarity transformation

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Solve numerically using bvp4c in MATLAB

↓

Stability Analysis

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Results and Discussion

RESULTS

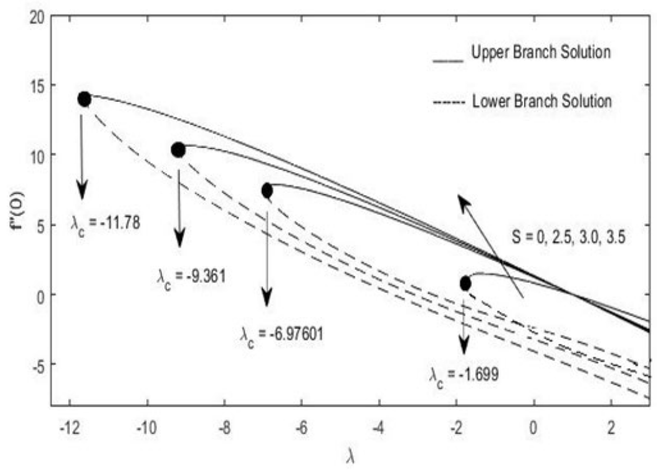

Fig. 2 Variation of the skin friction coefficient, $f''(0)$ when suction S=0, 2.5, 3.0, 3.5 with Q=0.6, β=0.5, Pr=1.0

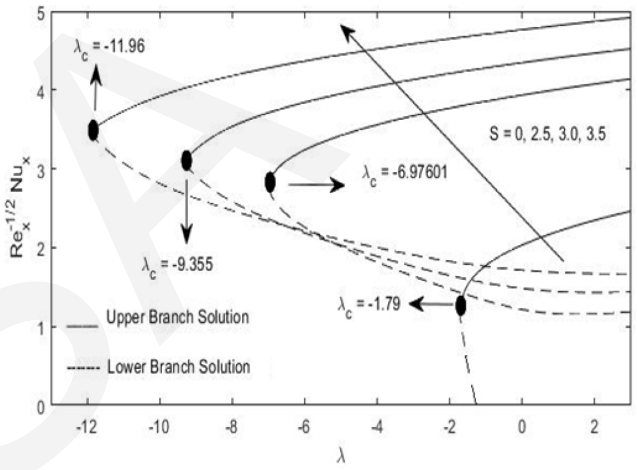

Fig. 3 Variation of the local Nusselt number, $Re_x^{1/2}Nu_x$ when suction S=0, 2.5, 3.0, 3.5 with Q=0.6, Rd=0.5, β=0.5, Pr=1.0

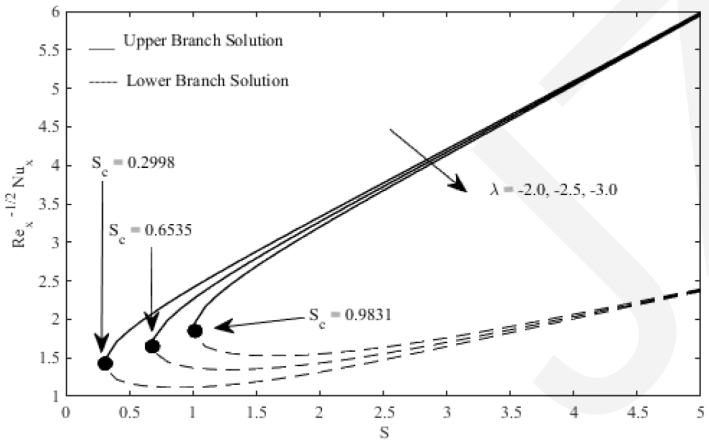

Fig. 4 Variation of $Re_x^{1/2}C_f$ when λ=−2.0, −2.5, −3.0 with Q=0.6, β=0.5, Pr=1.0

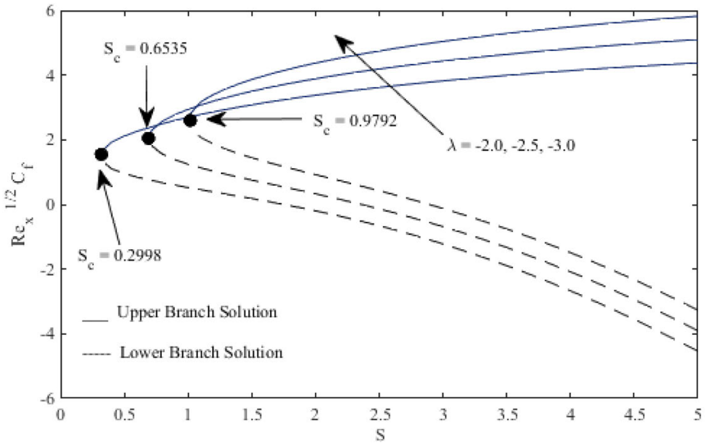

Fig 5 Variation of $Re_x^{-1/2}Nu_x$ when λ=−2.0, −2.5, −3.0 with Q=0.6, Rd=0.5, β=0.5, Pr=1.0

RESULTS

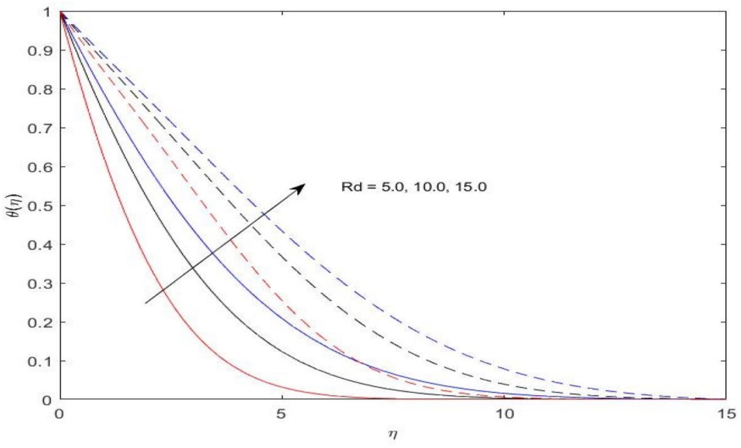

Fig. 6 Effect of Rd on the temperature profiles $\theta(\eta)$ with Q=0.6, λ=−2.0, β=0.5, η=15.0, Pr=1.0, S=2.0

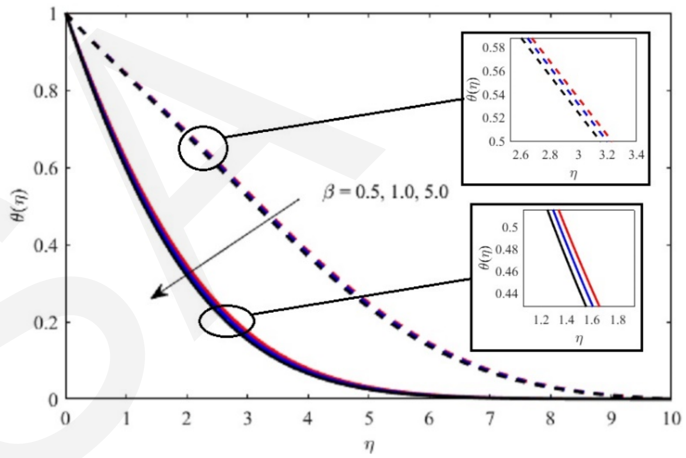

Fig. 7 Effect of β on the velocity profiles $f'(\eta)$ with Q=0.6, Rd=5.0, λ=−2.0, η=15.0, Pr=1.0, S=2.0

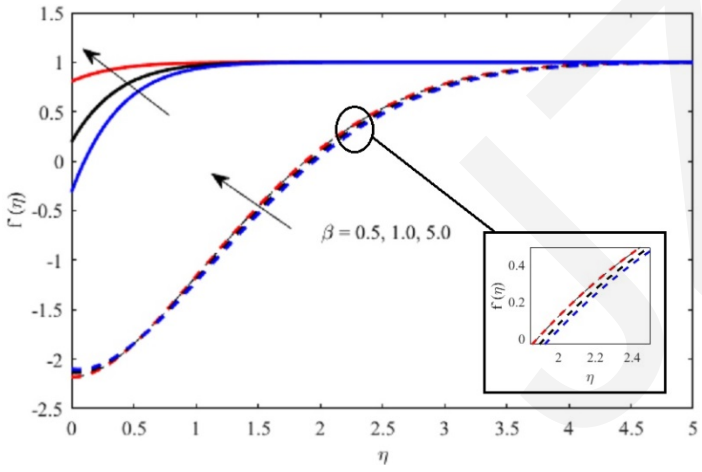

Fig. 8 Effect of β on the temperature profiles $\theta(\eta)$ with Q=0.6, Rd=5.0, λ=−2.0, Pr=1.0, S=2.0

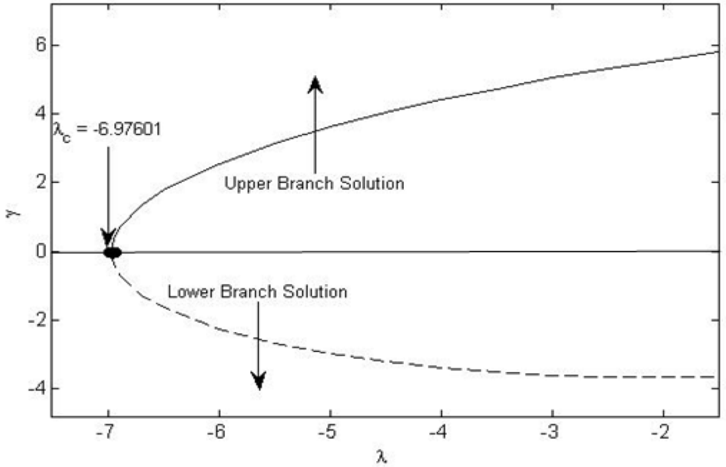

Fig. 9 The smallest eigenvalues γ for selected values of λ with Pr=1.0, β=0.5, Rd=5.0

MAIN FINDINGS

- Dual solutions (upper and lower branches) are found for a single value of parameter for both stretching and shrinking cases.
- The skin friction coefficient and the heat transfer rate at the surface increase as the strength of suction is increased.
- The skin friction coefficient decreases as the stretching/shrinking parameter λ increases, for both solution branches.
- The local Nusselt number which represents the heat transfer rate at the surface increases for the upper branch solution but decreases for the lower branch solution.
- Radiation enhances the temperature inside the boundary layer.
- Increasing the slip effect enhances the velocity but lessen the temperature inside the boundary layer.
- The temporal stability analysis shows that only the upper branch solution is stable in a long run.