Heat transfer in a square cavity with side heating (both vertical sides are isothermal)

A square cavity is filled with a near-critical fluid under ground-based conditions (acceleration of gravity force is vertical and pointed down). The temperature on the left side is increased quickly on $0{,}1\,K$ and then it is fixed. The temperature on the right side is equal to initial one. The arisen uniform temperature difference on vertical sides leads to gravitational convection. The flow is unsteady at the initial moments, but it transforms into steady one in a long period. Horizontal sides are adiabatic. The following parameters are used:

$$Ra = 10^3,\ \Pr = 1,\ \mathrm{Re} = 3{,}85\cdot 10^4,\ \varepsilon = 3{,}3\cdot 10^{-3},\ \Theta = 3{,}3\cdot 10^{-4},$$
$$\gamma_0 = 1{,}4,\ \vec{g} = (0,-1),\ \Lambda = 0{,}028,\ \psi = 0{,}74$$

Near-critical fluid is compared with perfect gas characterized by criteria

$$Ra = 6{,}06\cdot 10^6,\quad \Pr = 30$$

which defined with the help of [the calibration laws].

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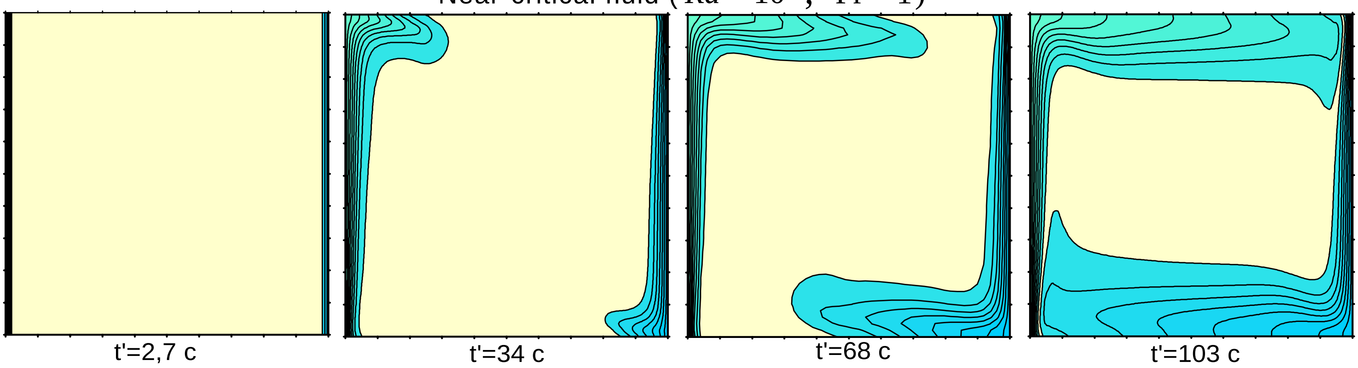
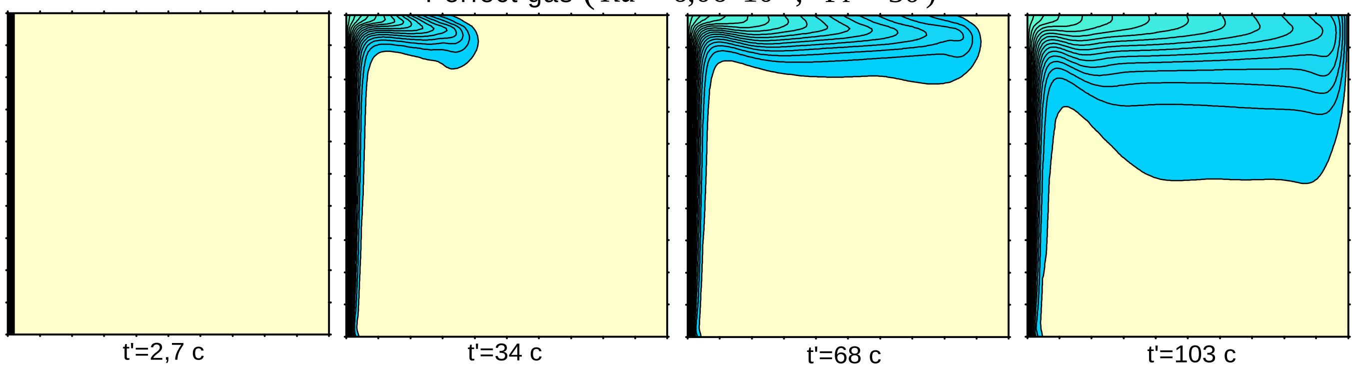
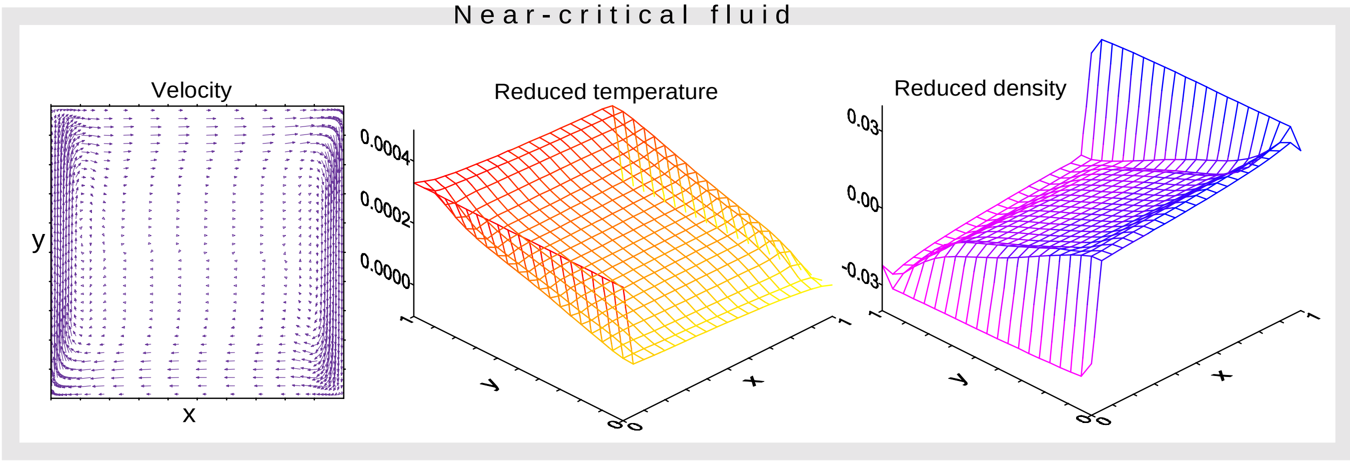
Near-critical fluid ($Ra = 10^3,\ \Pr = 1$)

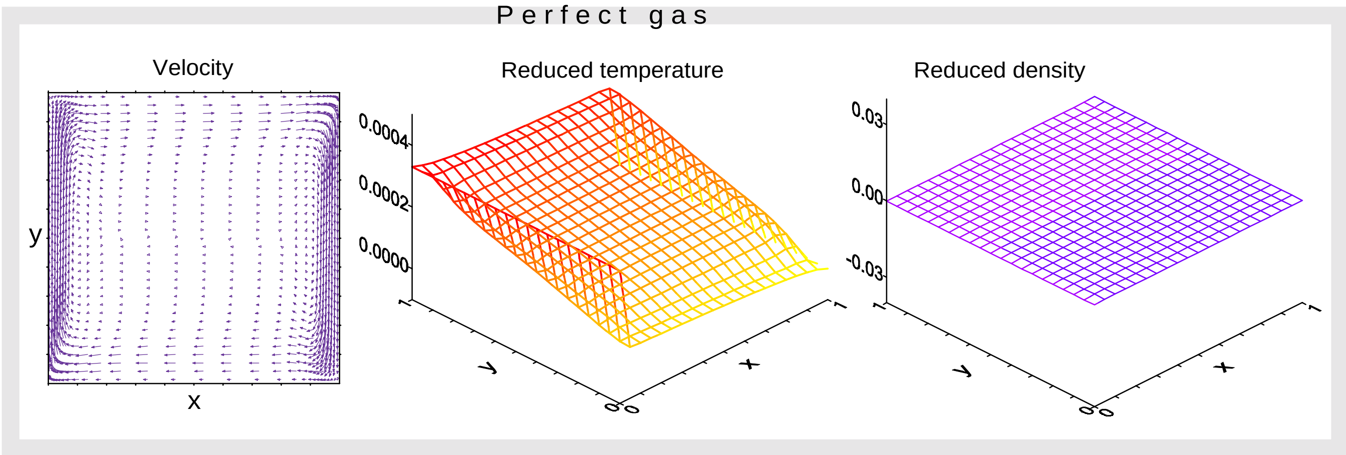


Perfect gas ($Ra = 6{,}06\cdot 10^7,\ \Pr = 30$)



The temperature fields (isotherms) correspond to unsteady motions in a near-critical fluid (upper) and in a perfect gas (lower). Owing to the Piston-effect the fast bulk heating in the first case leads to the generation of two streams near the vertical boundaries.





The thermal and dynamic fields of a near-critical fluid and a perfect gas are similar in the steady-state regime, but the fields of density differ from each other very strongly because of hypercompressibility in a near-critical fluid. Obtained particular similarity justifies the calibration laws.

See [9, 16] in PUBLICATIONS

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