Transitional modes of penetrative convection in plain layer

- BIFD 2011 -

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ABSTRACT

Peculiarities of transition to chaotic motions in a plain layer of water with fixed temperatures on the boundaries are considered in the case of the temperature interval comprising the temperature of density maximum. State stable and unstable layers may form within the layer, depending on the position of the point of density maximum in the conductive state. For the interval of temperatures considered (1^oC-7^oC) quadratic dependency of density on temperature is assumed. The flow meets conditions for Boussinesq approximation and is two-dimensional.

We are looking for periodic solutions with reflectional symmetry in a plain layer. Such conditions correspond to boundary conditions of absence of viscous stress on some vertical boundaries of periodicity cell. Meanwhile we are looking for solutions which are stable for quite large aspect ratio (up to 20 lengths taken from linear theory), so investigation of aspect ratio in fully nonlinear modes was of quite importance and in this present work differs from majority of works devoted to scenarios of transition to chaos in RBC. Indeed after the bifurcation of period doubling horizontal period also increased twice to be stable. Numerically pseudospectral method was used with free stress boundary conditions and resolution up to 1024x256 harmonics for large aspect ratio. In the case when stable and unstable layers are equal, we have found that the principle scenario of transition to chaos with growth of supercriticality is fulfilled through: subcritical loss of stability of static solution, Hopf limit cycle bifurcation, doubling of limit cycle, quasi-periodic solution, solution with intermittency between quasi-periodic and stochastic bursts, and fully stochastic motion. At the same time we show rearrangement of hydrodynamic structure of flows after bifurcations. The periodical motion occurs through formation and periodical motion of vortices near the upper boundary (in classical convection for the same boundary condition little vortices are formed and circularly move in the large ones), Corresponding temperature profile have a form of "tails" - vertically elongated structures with fixed upper part and oscillating lower part. After period doubling reflectional symmetry is lost again and "tails" begin to move asynchronously. Along with the described scenario of transition to chaos there may exist hysteresis and alternative flows were described. For the same parameters there may exist different types of stable solutions, f.e. periodical and two static solutions with different aspect ratio. Quasiperiodical solutions may be unstable for large aspect ratios. Some preliminary results are published [1].

REFERENCES

[1] D. V. Kuznetsova and I. N. Sibgatullin, “Transitional Regimes of Penetrative Convection in a Plain Layer”, *Doklady Physics*, Vol. **56**, pp. 271–274 (2011).