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Thermal convection in dielectric liquids in a cylindrical annulus[1]

INNOCENT MUTABAZI, CHANGWOO KANG, ANTOINE MEYER, Normandie Universite, MARTIN MEIER, CHRISTOPH EGBERS, Brandenburg University of Technology — Thermal convection is investigated in a dielectric liquid of thermal expansion coefficient α, kinematic viscosity ν, thermal diffusivity κ and electric permittivity ε in a cylindrical annulus of inner radius a and outer radius $b$with a radial temperature gradient and a high-frequency electric tension. The coupling between the electric field and the gradient of the permittivity yields the dielectrophoretic force. The control parameters are η = a/b, Pr = ν/κ, the classic Rayleigh number Ra = $\alpha\Delta$T gd$^3/\nu\kappa$, and the electric Rayleigh number L = $\alpha\Delta$T g$_e$d$^3/\nu\kappa$ The electric gravity g$_e$ is the gradient of the electric energy in the condenser. Linear stability analysis shows that for infinite annulus, depending on values of η, Ra and L, critical modes are either hydrodynamic or thermal modes, helical electric modes or columnar vortices. Experiments in an annulus of aspect ratio Γ =19.6 during parabolic flight campaigns indicate the existence of columns. Columnar vortices result from the competition between Archimedean buoyancy and dielectrophoretic force. Direct numerical simulations in the annulus of Γ =20 show that the columnar vortices occupy the central part of the annulus, while near the end-zones the flow is laminar and dominated by an azimuthal vorticity.

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