Meandering of the large-scale circulation of turbulent convection in a cylindrical cell

ERIC BROWN, DENIS FUNFSCHILLING, ALEXEI NIKOLAENKO, GUENTER AHLERS, Dept. of Physics and iQUEST, UC Santa Barbara — The large-scale circulation (LSC) in cylindrical cells of aspect ratio $\Gamma \equiv D/L = 1$ ($D =$ diameter, $L =$ height) filled with water at a mean temperature of 40°C and heated from below was studied for Rayleigh numbers $R$ in the range $10^9$ to $10^{11}$. We measured the temperatures of the cell side-wall as a function of time $t$ at eight azimuthal locations on the horizontal mid-plane and from them deduced the azimuthal orientation $\theta(t)$ of the LSC. We found that $\theta(t)$ varied irregularly in time. Although it had a preferred value, on average there was a long-term continuous rotation of the LSC. From the data for $\theta(t)$ we derived $\dot{\theta} \equiv \Delta \theta / \Delta t$ ($\Delta t$ is the time interval between measurements). The time averages of $\dot{\theta}(\theta)$ gave a deterministic force $-\partial V / \partial \theta$ corresponding to a potential of the form $V = V_0 [-\cos(\theta - \theta_0) + v_1 \theta]$, and its probability distribution-function $P_\dot{\theta}(\dot{\theta})$ yielded a Langevin force $f(t)$. Integrations of the corresponding stochastic model equation $\partial \theta / \partial t = -\partial V / \partial \theta + f(t)$ produced time series $\theta(t)$ and distribution functions $P_\theta(\theta)$ remarkably similar to the experimental data. We attribute $f(t)$ to the action of the turbulent background fluctuations on the LSC, and found that its intensity depended on $R$.

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