The onset of particle-dominated convection regime in colloidal suspensions

LAYACHI HADJI, MAHMOUD DARASSI, The University of Alabama — In the experiments of Bénard convection in a suspension of microparticle by Chang et al. (2008), a parameter $\beta$ was isolated to model the interplay between the effects of thermophoresis, sedimentation and Brownian diffusion. A plot of $\beta$ as function of the particle radius, $r_p$, for a suspension of aluminum oxide particles in water shows that the function $\beta(r_p)$ has the shape of an inverted parabola with two roots so that $0 < \beta \ll 1$ for $1 \text{ nm} \leq r_p \leq 5 \text{ nm}$ and for $r_p \approx 50 \text{ nm}$ where thermophoresis and sedimentation are balanced. We consider a particulate medium model to determine the threshold instability conditions. Due to the large particle size, the convection process is characterized by longer diffusion time scale, much smaller Lewis number, $\tau$, and larger separation ratio, $S$, than the binary mixture case. For $0 < \beta \ll 1$ which corresponds to two distinct particle radii, a small wavenumber expansion yields the value $R_c = 720 \tau / S$. For $\beta = O(1)$, threshold stability conditions are depicted as function of the particle size and the height of the fluid cell.