Multiscale Dynamics of 2D Rotational Compressible Euler Equations  
– an Analytical Approach

Bin Cheng∗  
*University of Michigan, USA  
bincheng@umich.edu  
Eitan Tadmor  
University of Maryland, USA  
tadmor@cscamm.umd.edu

We study the 2D rotational incompressible Euler equations with two singular parameters: the Rossby number $\tau$ for rotational forcing and the Froude/Mach number $\sigma$ for pressure forcing. The competition of these two forces leads to a newly found parameter $\delta = \tau\sigma^{-2}$ that serves as a characteristic scale separating two dynamic regimes: $\delta \ll 1$ for the strong rotation regime ([1]) and $\delta \gg 1$ for the mild/weak rotation regime ([2]).

The analytical novelty of this study is correspondingly two-fold. In the $\delta \ll 1$ regime, we utilize the method of iterative approximations that starts with the pressureless rotational Euler equations previously studied in [3]. The resulting approximation is a periodic-in-time flow that reflects the domination of rotation in this small $\delta$ regime. On the other hand, for $\delta \gg 1$, we combine fast wave analysis for nonlinear hyperbolic PDEs with Strichartz type estimates to reveal an approximate incompressible flow. Our argument is highlighted with an invariant-based analysis on the nonlinear interations of fast waves and therefore is potentially easy to generalize.

References

