A comparison of vortex and pseudo-spectral methods at high Reynolds numbers ANTHONY LEONARD, GALCIT, California Institute of Technology, WIM VAN REES, PETROS KOUMOUTSAKOS, Chair of Computational Science, ETH Zurich, CH-8092, Switzerland — We validate the hybrid particle-mesh vortex method against a pseudo-spectral method in simulations of the Taylor-Green vortex and colliding vortex tubes at Re = 1600 - 10,000. The spectral method uses the smooth filter introduced in [1]. In the case of the Taylor-Green vortex, we observe very good agreement in the evolution of the vortical structures albeit small discrepancies in the energy spectrum only for the smallest length scales. In the collision of two anti-parallel vortex tubes at Re = 10 000, there is very good agreement between the two methods in terms of the simulated vortical structures throughout the first reconnection of the tubes. The maximum error in the effective viscosity is below 2.5% and 1% for the vortex method and the pseudo-spectral method respectively. At later times the agreement between the two methods in the vortical structures deteriorates even though there is good agreement in the energy spectrum. Both methods resolve an unexpected vortex breakdown during the second reconnection of the vortex tubes.

[1] Hou, T. and Li, R., 2007. Computing nearly singular solutions using pseudo-spectral methods. J. of Comput. Phys., 226:379-397.

Petros Koumoutsakos
Chair of Computational Science, ETH Zurich, CH-8092, Switzerland