Abstract Submitted
for the DFD14 Meeting of
The American Physical Society

An effective fractal-tree closure model for simulating blood flow in large arterial networks PARIS PERDIKARIS, Brown University, LEOPOLD GRINBERG, IBM T.J Watson Research Center, GEORGE KARNIADAKIS, Brown University — The aim of the present work is to address the closure problem for hemodynamics simulations by developing a flexible and effective model that accurately distributes flow in the downstream vasculature and can stably provide a physiological pressure outflow boundary condition. We model blood flow in the sub-pixel vasculature by using a nonlinear 1D model in self-similar networks of compliant arteries that mimic the structure and hierarchy of vessels in the meso-vascular regime. The proposed model accounts for wall viscoelasticity and non-Newtonian flow effects in arterioles, overcomes cut-off radius sensitivity issues by introducing a monotonically decreasing artery length to radius ratio across different generations of the fractal tree, and convergences to a periodic state in just two cardiac cycles. The resulting fractal trees typically consist of thousands to millions of arteries, posing the need for efficient parallel algorithms. To this end, we have developed a scalable hybrid MPI/OpenMP solver that is capable of computing near real-time solutions. The proposed model is tested on a large patient-specific cranial network returning physiological flow and pressure wave predictions without requiring any parameter estimation or calibration procedures.

Paris Perdikaris
Brown University

Date submitted: 31 Jul 2014 Electronic form version 1.4