Combined BSM and DSMC for Filter Flows in Partial-Slip and Transition Regimes

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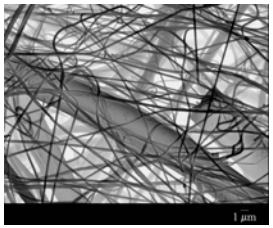
Objectives

- To develop boundary singularity method for filtration flows through multi-modal micro- and nano-scale filters with irregular matrix
- To obtain the flowfield, pressure drop and particle capture mechanisms crucial to filter performance in the partial-slip and transition flow regimes

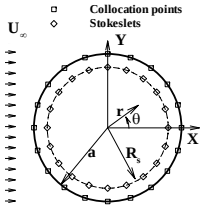


Fibrous media with multimodal fiber diameters

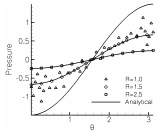
BSM & DSMC

- The Boundary Singularity Method (**BSM**) is combined with the partial-slip boundary conditions for partial-slip flows. *The BSM does not require volume meshing!*
- A hybrid method of BSM and DSMC is proposed for filtration flows in the transition flow regime

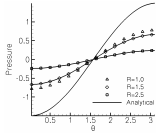
Schematic for BSM



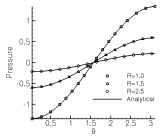
BSM with submerged Stokeslets



Regular Stokeslets

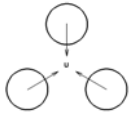


Regularized Stokeslets

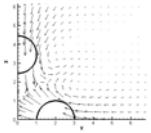


Submerged Stokeslets

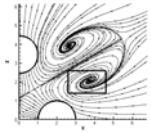
Flows about ensembles of particles



Assembling spherical particles



Velocity vectors

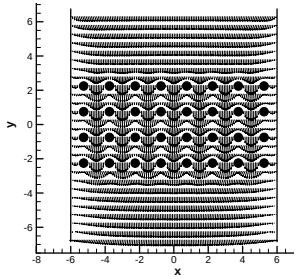


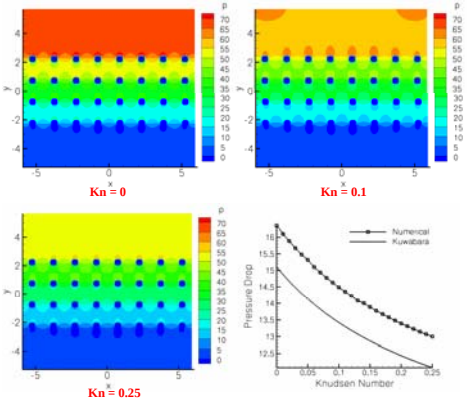
Flow trajectories

- A quasi-steady approximation was used
- The obtained circulation for no-slip boundary conditions over the marked rectangular area is 20% bigger than that for partial-slip boundary conditions with Kn = 0.1

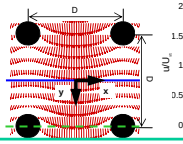
Fibrous filter flows

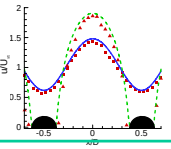
Flow field about a representative 4×8 set of fibers





Pressure distribution as a function of Kn number



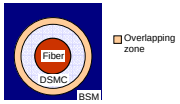


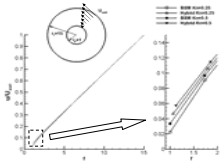
Comparison of our BSM computations with experiments by U. ofToronto

- The packing fraction $c = \frac{\pi a^2}{D^2} = 5\%$
- The number of rows of fibers is 8
- The number of columns is 14

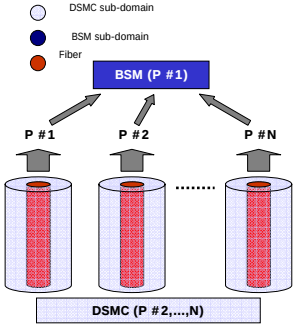
Work in progress: coupling of BSM and DSMC

Schematic for the coupling





Preliminary results for the Taylor-Couette flow



- DSMC is assigned to a separate processor per fiber (P #1, …, N)
- BSM is assigned to a single processor
- DSMC and BSM interact through the interface boundary conditions

Parallel computing of filtration flows using hybrid continuum BSM and molecular DSMC