# Electric and Hydrodynamic Properties of Stem Cells with Realistic Three-Dimensional Morphologies

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The effective properties of a dilute suspension of particles have a strong dependence on the particle electric and magnetic polarizability tensors. Moreover, several hydrodynamic properties such as the hydrodynamic radius, intrinsic viscosity and intrinsic solvent diffusivity can be derived from the electric and magnetic polarizability tensors using simple proportionality relations (see for example D. Audus et al., Soft Matter, vol. 11, pp. 3360-3366, 2015). The goal of this study is to evaluate the electric and magnetic polarizability tensors of stem cells, with realistic three-dimensional (3D) morphologies, to explain the dilute suspension properties of these cells. Moreover, these polarizability tensors are necessary for quantifying the motion of stem cells due to an exerted electric field in the processes of Dielectrophoresis and Electrotaxis.

A database of realistic three-dimensional (3D) stem cell shapes, achieved experimentally using confocal microscopy, was recently presented (P. Bajcsy et al., Journal of Microscopy, vol. 260, no. 3, pp. 363–376, 2015.). The database consisted of ten different families of stem cells represented in both STL (STereoLithography) and volumetric mesh formats. The stem cells in the different families were grown in different 3D scaffolds, which provided different structural queues and regulated the stem cells' 3D morphology. Due to the complexity of the 3D stem cell morphology, we used multiple independent methods to validate our results. Specifically, we used SCUFF-EM, which is an open source Method of Moment (MOM) solver, COMSOL Multiphysics, which is a finite element solver, ZENO, which is a Monte Carlo numerical path integration solver, as well as an in-house finite element package operating directly on a voxel representation of the particles. Using these solvers, we obtained the electric polarizability tensor, the magnetic polarizability tensor, and the intrinsic conductivities for one stem cell shape from each of the ten families. From these electrostatic properties, we also calculated the corresponding hydrodynamic properties of the stem cells. A detailed comparison of the accuracy and the computational efficiency of each computational method, based on the fidelity of shape representation, will be presented. The results of our computational experiments show that the 3D shape of stem cells has a strong effect on their electric and hydrodynamic properties.