Modelling drop-drop interactions in an atomic force microscope

*S.L. Carnie , Derek Y.C. Chan, Craig Lewis and Rogério Manica

The University of Melbourne, Melbourne, Australia

Recent experimental developments have enabled dynamical measurement of the force between two liquid drops in solution using an Atomic Force Microscope (AFM). The drop sizes (around 40 microns radius) and approach velocities (up to 10 microns per second) used in the experiments produce a regime where surface forces, hydrodynamics and drop deformation are all significant.

A detailed model of the experimental set up which accounts for surface forces, hydrodynamic interactions, droplet deformation and AFM cantilever deflection has been developed. In full agreement with experimental observations, the calculated force curves show pseudo-constant compliance regions, due to drop flattening, as well as attractive pull-off forces, due mainly to hydrodynamic lubrication forces.

A novel feature of the model is the use of matched asymptotic expansions to derive a new asymptotic boundary condition for drops with constant relative velocity. This boundary condition is necessary to obtain results independent of the size of the computational domain. Semi-discretization of the resultant equations produces a differential-algebraic system of index 1, which is solved by standard methods.