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New Model for Deep Indentation by Spherical AFM probes

KIARASH RAHMANI ELIATO, BRYANT DOSS, ROBERT ROS, ASU department of Physics — Atomic Force Microscopy (AFM) based micro rheology has evolved to a key tool in the study of mechanical properties of biological materials. Spherical indenters and contact mechanic models like the Hertz model are most frequently used for soft materials like cells and hydrogels. However, the Hertz model is limited to shallow indentations due to the model's first order geometry function approximation. Deep indentation provides stiffness information of the sample through its depth. In this work we present a model base on the second-order approximation of sphere geometry and Sneddon's solution for such a geometry. To test this model, polyacrylamide gel were used to collect experimental data both, for quasi-static (e.g. Young's moduli) and dynamic (e.g. Shear Storage and Loss moduli) quantifications. Further, we verified the model by Finite Element Simulations. We found that our model shows constant Young's moduli and more homogenous shear storage moduli through the indentation up to the radius of the probe (e.g. 2.7 m), while the Young's and shear storage modulus calculated with the Hertz model shows a decrease with the indentation depth. We anticipate that our new model opens the door for accurate deep AFM indentation measurements..

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