Abstract Submitted
for the DFD13 Meeting of
The American Physical Society

Shear Stress induced Stretching of Red Blood Cells by Oscillating Bubbles within a Narrow Gap FENFANG LI, MILAD MOHAMMADZADEH, CLAUS-DIETER OHL, Division of Physics and Applied Physics, School of Physical and Mathematical Sciences, Nanyang Technological University, Singapore 637371, CLAUS-DIETER OHL TEAM — The flow pattern, especially the boundary layer caused by the expanding/contracting bubble in a narrow gap (15 μm) and the resultant stretching of red blood cells is investigated in this work. High speed recordings show that a red blood cell (biconcave shape, thickness of 1-2 μm) can be elongated to five times its original length by a laser-induced cavitation bubble within the narrow gap. However, flexible cancer cells in suspension (RKO, spherical shape, diameter of 10-15 μm) are hardly elongated under the same experimental condition. We hypothesize that the shear stress at the boundary layer is crucial for this elongation to occur. Therefore, in order to resolve the related fluid dynamics, we conducted numerical simulations using the finite element method (Fluent). The rapidly expanding/contracting vapor bubble is successfully modeled by employing viscosity and surface tension. The transient pressure inside the bubble and the velocity profile of the flow is obtained. We observe strong shear near the upper and lower boundary during the bubble oscillation. The flow fields are compared with analytical solutions to transient and pulsating flows in 2D. In the experiment the red blood cells sit within the lower boundary layer, thus are probably elongated by this strong shear flow. In contrast, the spherical cancer cells are of comparable size to the gap height so that they are lesser affected by this boundary layer flow.

Fenfang Li
Division of Physics and Applied Physics, School of Physical and Mathematical Sciences, Nanyang Technological University, Singapore 637371

Date submitted: 30 Jul 2013 Electronic form version 1.4