Axisymmetric thermocapillary motion of a deformable fluid droplet in an insulated tube

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The axisymmetric motion of a deformable fluid droplet in an insulated tube filled with a second fluid and subject to an imposed constant axial temperature gradient is analyzed numerically in the limit of vanishing Reynolds and Marangoni numbers. A scalable parallel program is developed which distributes 2D blocks of submatrices of a dense matrix among process grids according to the 2D block-cyclic distribution scheme described in ScaLAPACK and calls the routine PDGESV to invert the matrix. Running the parallel code on the SGI 3400 server with 32 CPUs, the parallel code runs about 10-time faster than the serial code, which runs on a PC with an Intel Pentium 4 processor.

For the parameters studied, droplet deformations are noticeable only when the drop to the continuous phase conductivity ratio, $\kappa = 10^{-5}$, and the drop to tube diameter ratio, $a/b \geq 0.8$. Under these conditions, higher pressure develops in the continuous phase in order to drive fluid through an increasingly smaller gap between the drop surface and the tube wall, interfacial tension gradients also increase rapidly because heat is now conducted through a smaller gap. The increased pressure results in an increased difference of the normal stress jump between the front and the back of the drop. The transition of the normal stress jump between the front and the back becomes sharper compare to the profile of interfacial tension and drop deforms as a result of matching this condition. The curvature at the front of the drop increases while the curvature at the back decreases because interfacial tension is the lowest at the front and highest at the back. Steady drop migration velocity in a confined geometry is always less than the velocity in an infinite medium. The confined geometry begins to show its influence on the migration velocity when $a/b \geq 0.3$. For $\kappa = 10^{-5}$ and $a/b \geq 0.5$, migration velocity of a deformable droplet is greater than the velocity computed with the assumption that droplet remains spherical during its motion.