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Creeping Flows Past a Partially Engulfed $2D$ Multiphase Droplet[1]

D. PALANIAPPAN, Texas A&M University at Qatar — The reflection principle is used to construct closed form exact solutions for the two-dimensional perturbed flow fields in the presence of a $2D$ vapor-liquid compound droplet in the limit of low-Reynolds number. The geometry of the multiphase droplet is composed of two overlapping infinitely long cylinders C_a and C_b of radii a and b, respectively, intersecting at a vertex angle $\frac{\pi}{2}$. The composite inclusion has the shape resembling a $2D$ *lens* type of object with a vapor cylinder C_a partly protruded into a fluid cylinder C_b with a viscosity different from that of the host fluid. The mathematical problem with this twin-circular assembly in the Stokes flow environment is formulated in terms of Stokes stream function with mixed boundary conditions at the boundary of the hybrid droplet. General expressions for the perturbed stream functions in the two phases are obtained in a straightforward fashion using Kelvin's inversion together with shift and reflection properties of biharmonic functions. The general results are then exploited to derive singularity solutions for the hybrid droplet embedded in several unbounded non-uniform flow fields. The exact solutions are utilised to plot the streamline topologies and they show interesting flow patterns. While the flow fields exterior to the droplet exhibit back flow regions and compartmental divisions, the interior flow fields show existence of attached eddies and stagnation points (hyperbolic points). Surprising, but interesting flow features are observed in the case of two-dimensional flows.

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