Compound Droplet in Extensional and Paraboloidal Flows
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Exact analytical solutions are found for the steady state creeping flow in
and around a vapor-liquid compound droplet, consisting of two orthogonally
intersecting spheres of arbitrary radii (a and b), submerged in axisymmetric
extensional and paraboloidal flows of fluid with viscosity $\mu^{(1)}$. The solutions
are presented in singularity form with the images located at three points: the
two centers of the spheres and their common inverse point. The important
results of physical interest such as drag force and stresslet coefficient are de-
riv"ed and discussed. These flow properties are characterized by two param-
eters, namely the dimensionless viscosity parameter: $\Lambda = \mu^{(2)}/(\mu^{(1)} + \mu^{(2)})$,
and the dimensionless parameter: $\beta = b/a$, where $\mu^{(2)}$ is the viscosity of
the liquid in the sphere (part of the compound droplet) with radius $b$. We
find that for some extensional flows, there exists a critical value of $\beta = \beta_c$
for each choice of $\Lambda$ in the interval $0 \leq \Lambda \leq 1$ such that the drag force is
negative, zero or positive depending on whether $\beta < \beta_c$, $\beta = \beta_c$, or $\beta > \beta_c$
respectively. For other extensional flows, the drag force is always positive.
The realization of these various extensional flows by simply changing the
choice of the origin in our description of the undisturbed flow field is also
discussed. In extensional flows where the drag force is always positive, we
notice that this force $D_e$ for vapor-liquid compound droplet is maximum
when $\beta \approx 1$ (i.e. two sphere have almost the same radii). Moreover, we find
the drag force $D_e$ is a monotonic function of $\Lambda$, i.e., the drag force for vapor-
liquid compound droplet lies between vapor-vapor and vapor-rigid assembly
limits. We also find that the maximum value of the drag in paraboloidal
flow depends on the viscosity ratio $\Lambda$ and significantly on the liquid volume
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