# Detachment force of particles from fluid droplets

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**ABSTRACT**

We consider two spherical solid particles adsorbed on the surface of, and located at the opposite poles of an incompressible fluid droplet. We calculate the deformation of the droplet and subsequent detachment of the particles under the influence of two opposite external forces applied to the particles at each end, as the magnitude of the forces is increased. The free-energy analysis is used to calculate the force-displacement curves for restoring forces that are generated as a result of the droplet deformation and displacement of the particles relative to each other. In the case of the particles being small compared to the droplet we solve the problem analytically. Once the particle has left the interface, the liquid bridge connecting the particle to the surface relaxes. Any stored energy in the liquid bridge from the distortion of the interface has to be dissipated as a result. We demonstrate that the dissipated energy becomes an increasingly dominant component of the work done during the detachment of particles, as the particle to droplet size ratio decreases. This indicates the existence of a significantly higher energy barrier to desorption of very small particles, compared to the one suggested by their adsorption energy alone. Extending our calculations to the case of prolate spheroids, we investigate the effect of dissipation upon the minimum detachment work for different aspect ratios of the particles. We find that, even in the absence of line tension, it is easier to remove elongated particles from fluid interfaces than spheres because of lesser viscous dissipation of energy. We also extend our calculations to situations where the contact line is pinned on the surface of the particles.