

Capillary Forces Between Corners

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Nearby interfacial objects mutually attract through capillary interactions in a shape-dependent mechanism commonly known as the Cheerios effect. It is a gravity and surface-wetting driven process that has been observed or postulated in dispersal of aquatic plant seeds[4], directed colloidal self-assembly[1] and locomotion of meniscus-climbing insects[3]. Thus far, focus has been primarily on objects initially far away or on a curved interface, cases where the interfacial deformation can be approximated by superposition of contributions from each individual objects. More recent studies elucidated the role of shape on the attraction between nearby objects using multipole expansions, and, in particular, on attraction near a sharp corner where there is a curvature singularity//cite//. Figure 1 presents qualitative observations of the attraction between two floating 1" wide acrylic triangles as they approach each other, viewed from above. For a large class of relative initial positions and orientations, they rotate such that corners kiss first, after which they will fold or slide into a more stable final configuration. Prior to kissing, it appears that attraction is localized to the corners due to the curvature singularity. To the best of our knowledge, the force of attraction due to corners have never been quantified before. In this letter, we show that it scales as a power law of distance. For the 60 ° corners in Figure 1, the force of attraction scales as $d^{14/5}$, where d is the distance between corners.

Consider two identical corners tethered in place with separation d defined as the distance between the tips of each corner as is schematically shown in //fig//. Pinning the contact line to the corners forms the boundary conditions of the deformed interface. It is a free surface which satisfies the Young-Laplace equation

$$\nabla^2 u = \frac{u}{l_c^2} \quad (1)$$

where u is the displacement from an initially flat surface, $l_c = \sqrt{\sigma/\rho g}$ the capillary length, σ the surface tension and ρg the specific weight.

//Show experimental set-up//

$$F \approx \frac{\sigma}{2} \int_C \left[\left(\frac{u^2}{l_c^2} - u_n^2 + u_t^2 \right) dt - 2u_n u_t dn \right] \quad (2)$$

the attractive force, F , by applying a force balance on a loop enclosing the meniscus[2]. u is the vertical displacement ... u/l_c is the hydrostatic term and the gradients are the ...

//As a check, show attractive force between spheres and compare with literature//

Force from deformation of meniscus. Measure Meniscus deformations - Verify using circles. Use for triangles for $d \gg l_c$ and $d \ll l_c$.

RESULTS

//Show derivation for conformal mapping on angles//
//Show u_x scaling for the inner and outer region//
//Show Force plot and regions of scaling//

DISCUSSION

What does this mean?

Force concentrated at vertices is much stronger than force between smooth edges.

FIGURES

Figure 1: Analog of introduction in figures
Figure 2: Schematic for experiment and representative results
Figure 3: Power law scaling and force vs. distances.
Figure 4: On the boundary integral methods

NOTES

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- [1] Fengqiu Fan and Kathleen J Stebe. Assembly of colloidal particles by evaporation on surfaces with patterned hydrophobicity. *Langmuir*, 20(8):3062–3067, 2004.
[2] Andong He, Khoi Nguyen, and Shreyas Mandre. Capillary interactions between nearby interfacial objects. *EPL (Europhysics Letters)*, 102(3):38001, 2013.

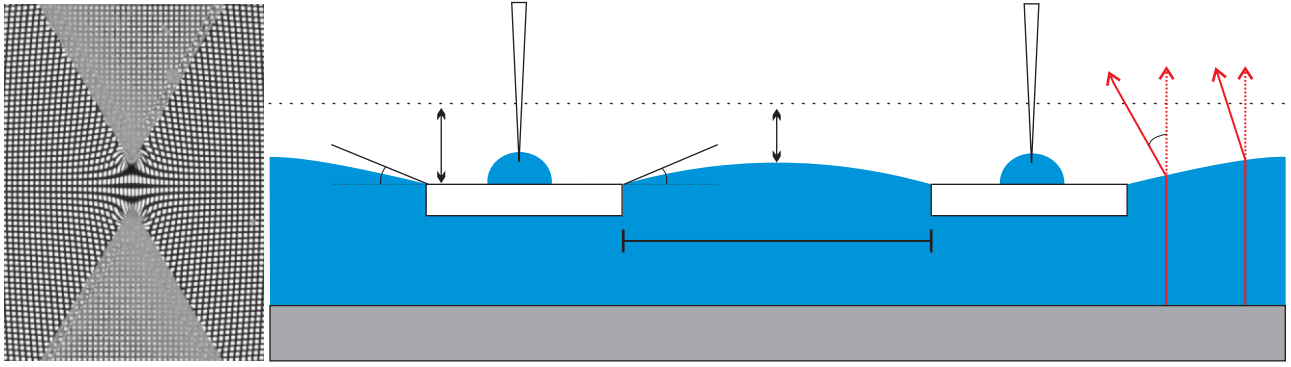


FIG. 1. Lorem ipsum dolor sit amet, consectetur adipisicing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex ea commodo consequat.

- [3] David L Hu and John WM Bush. Meniscus-climbing insects. *Nature*, 437(7059):733–736, 2005.
- [4] Paolo Peruzzo, Andrea Defina, Heidi M Nepf, and Roman Stocker. Capillary interception of floating particles by surface-piercing vegetation. *Physical review letters*, 111(16):164501, 2013.