Flow around a corner: visualizing electrostatics via hydrodynamics

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On the anti-duality of the electrostatic and fluid problems

Figure 1: On the anti-duality of the fluid (a) and electrostatic (b) problems [1] on the sector of angle \( \alpha = 2(\pi - \theta_m) \). Figure (c) shows the general sector angle dependence for the velocity potential \( \phi \sim r^{\nu} \Rightarrow v \sim r^{\nu-1} \), in particular \( \nu(\pi/2) = 0.814 \) and \( \nu(\pi) = 1/2 \).

Experimental setup

Figure 2: A flat-bottom plate with different corner angles \( \alpha \) is attached to a plunger of an electromagnetic solenoid, which drives it to impact the water surface. Velocity fields are obtained using a PIV system (TSI, Inc). Evolution of fluid parcels is captured by a PIV camera. Blobs of fluorescent particles are injected under the plate corners by the Harvard apparatus syringe pump (not shown) and illuminated by an expanded Nd:YAG laser beam. BNC Model 575 delay unit is used to control the photo capture timing.

PIV fields and fluid parcel deformations

Figure 4: PIV measurements (top images) confirm the analytically predicted increase in the singularity of the near-the-edge velocity with \( \alpha \). Taken from below the impactor plate images of the blobs of fluorescent particles injected right before the impact (left) and deformed 1 ms after the impact (right) illustrate the fluid parcels deformations: no side-wise stretching for \( \alpha = 180^\circ \), sidewise stretching for \( \alpha < 180^\circ \), and squishing for \( \alpha > 180^\circ \) as opposed to the 2D case (c).

Bibliography


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