

23rd IYPT Problem : Sticky Water

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Abstract

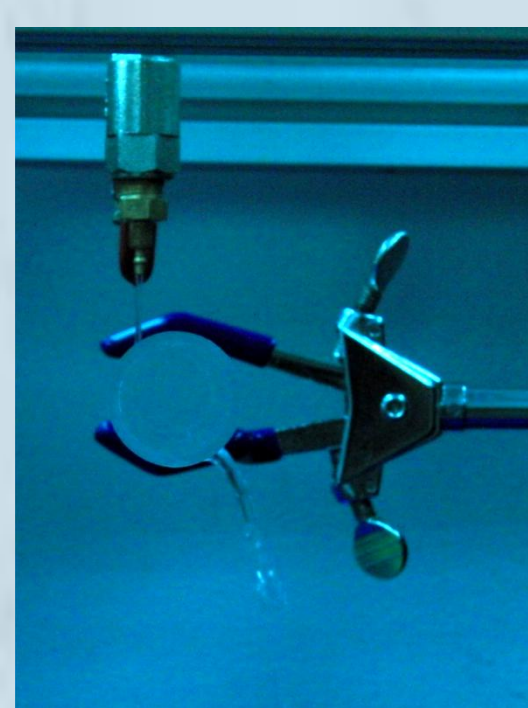
When a horizontal cylinder is placed in a vertical stream of water, the stream can follow the cylinder's circumference along the bottom and continue up the other side before it detaches. Explain this phenomenon and investigate the relevant parameters.

The phenomenon is an example of “Coanda Effect,” the tendency for a fluid jet to be attracted to a nearby surface. Water sticks on the cylinder due to wetting, and it detached because of fluid instability. Qualitative explanation for this effect is rare. In this note, we investigate the influence of the parameters experimentally. The results show us the complexity and instability of this phenomenon.

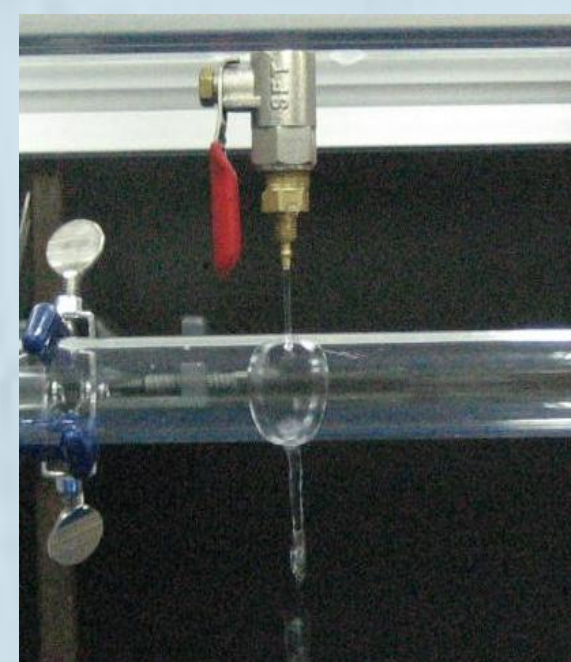
Experimental Setup



• Front view

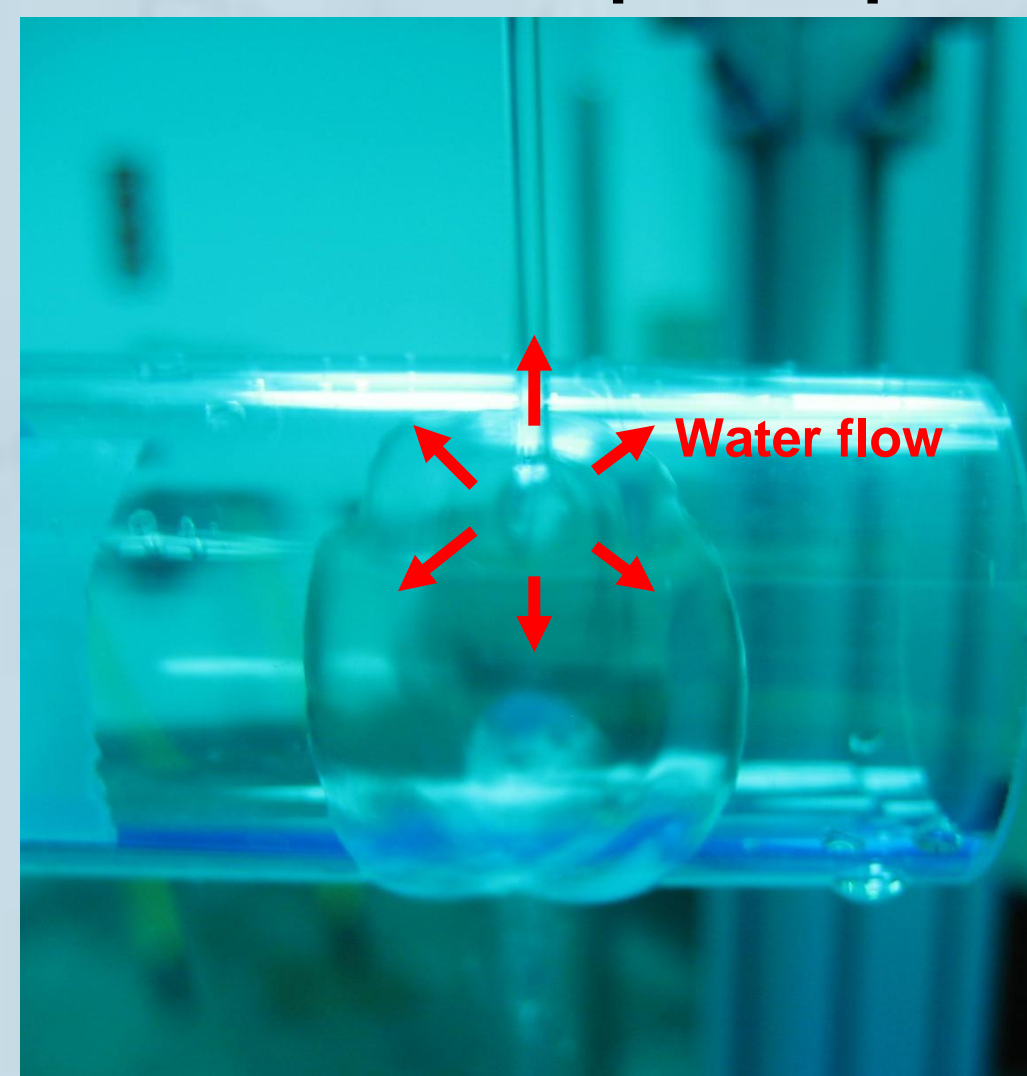


• Side view



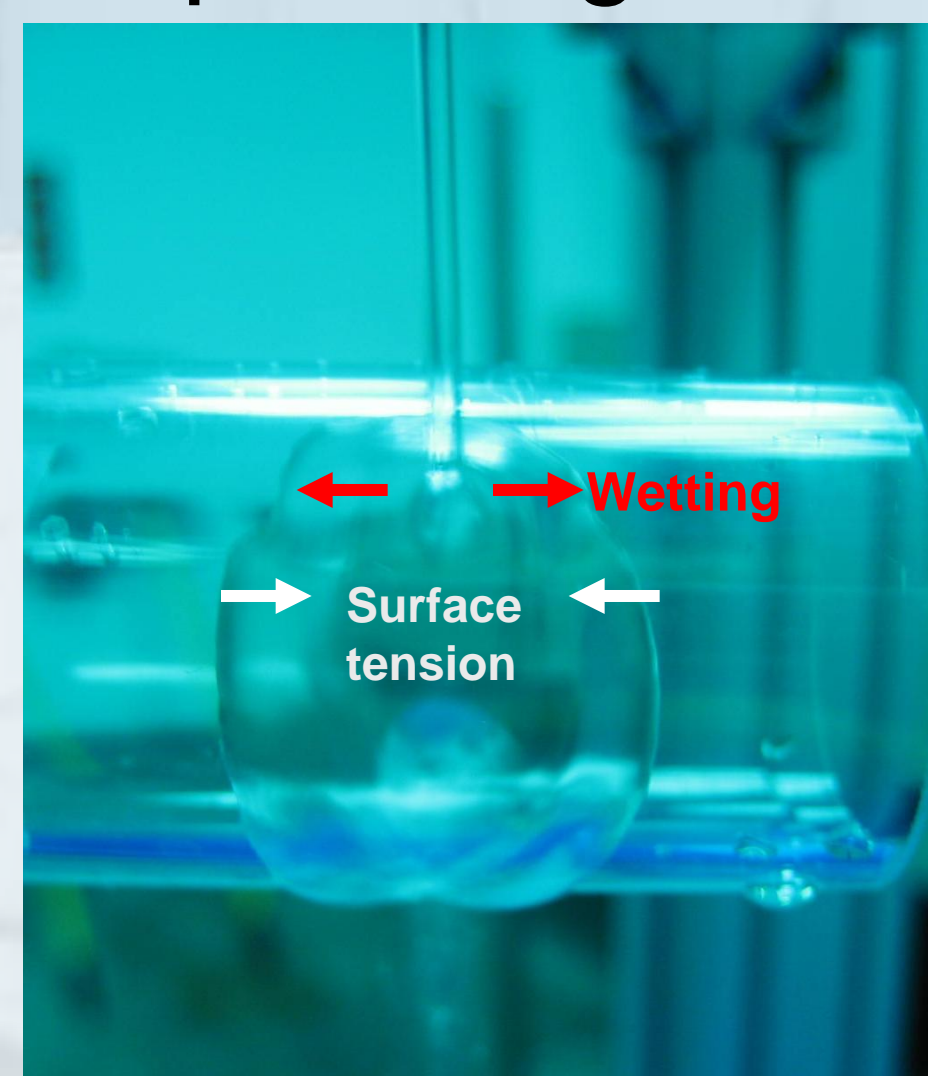
Results

1. At the impact point



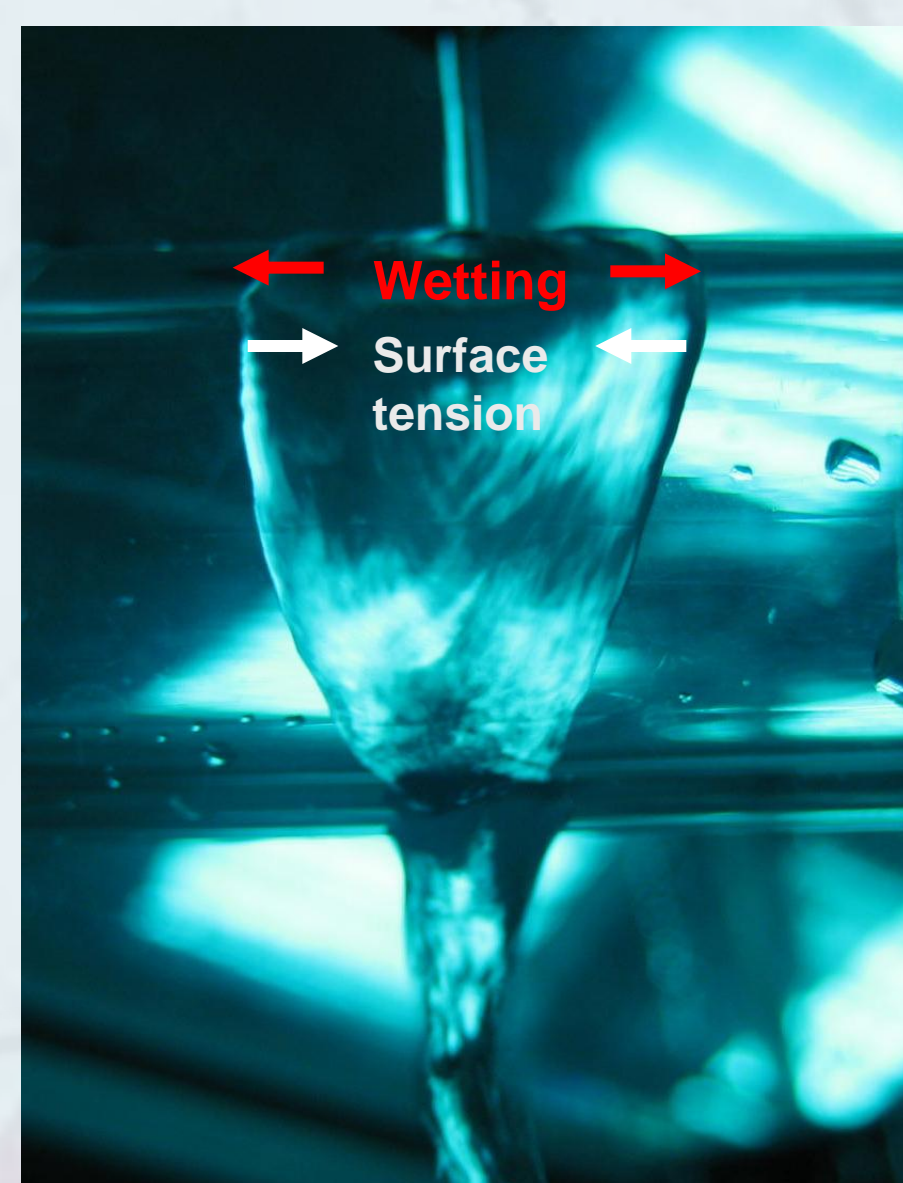
- Water spread out in every direction.
- There is more momentum (mv) in the forward direction.

2. Spreading Out



- The water jet flows down due to gravity.
- The velocity will be different at different point.

3. Convergence



- The stream converges because:
 - The velocity is greater,
 - Evidently, the cohesion wins over the wetting.

4. Detachment

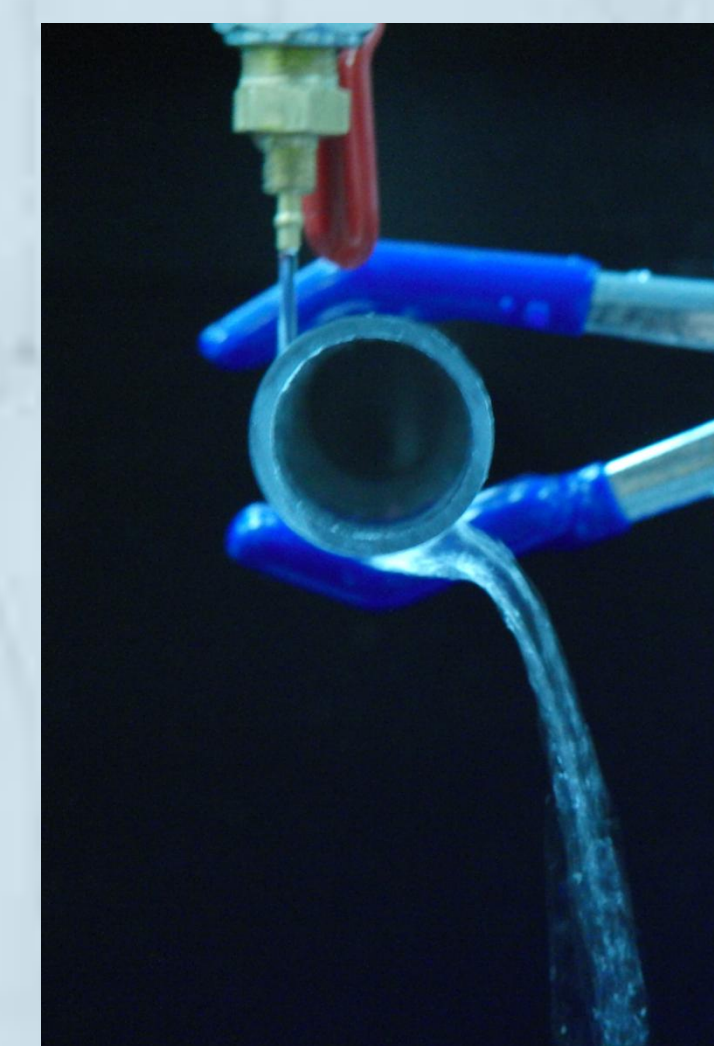
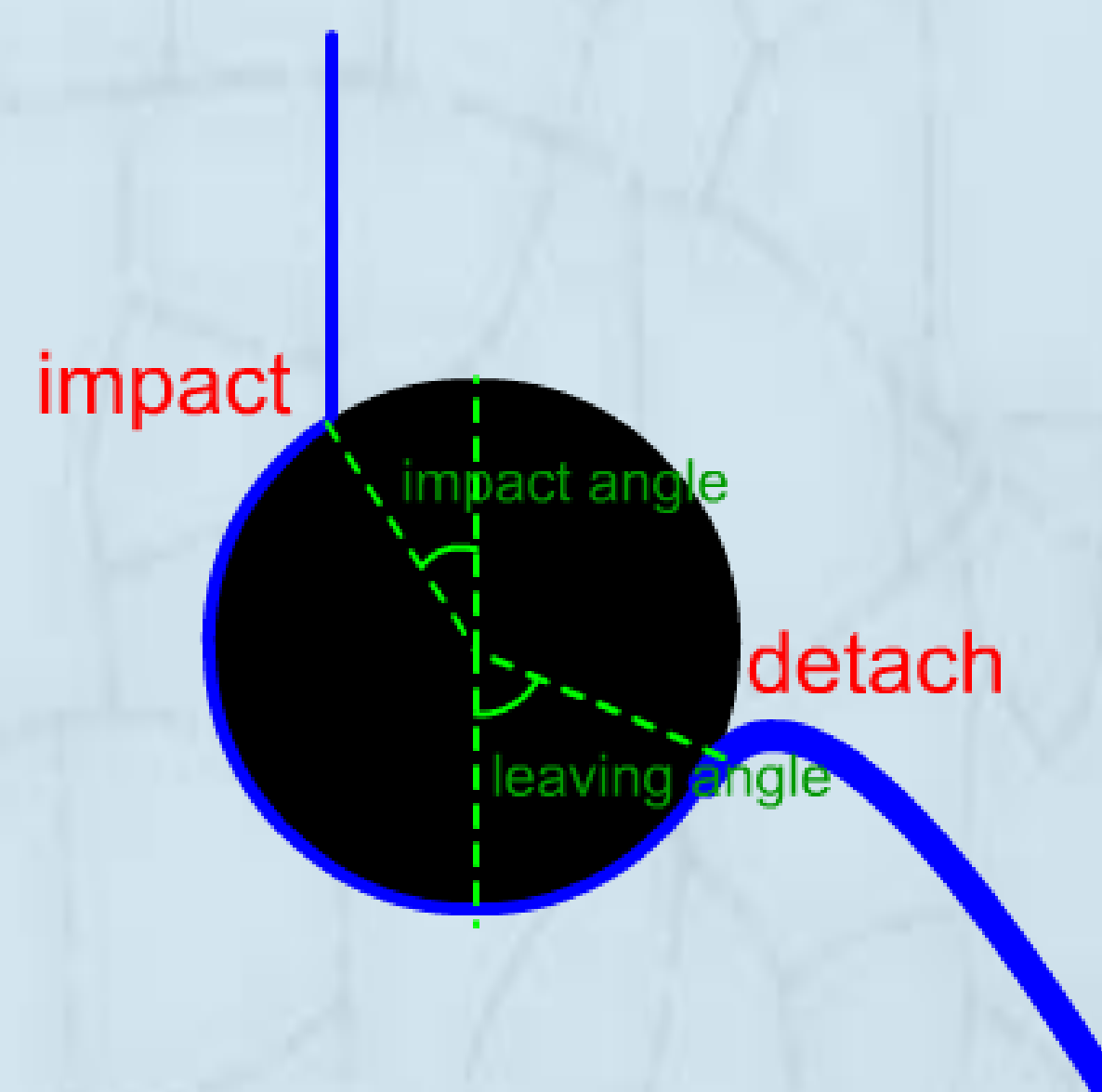


- Fluid instability results in detachment.

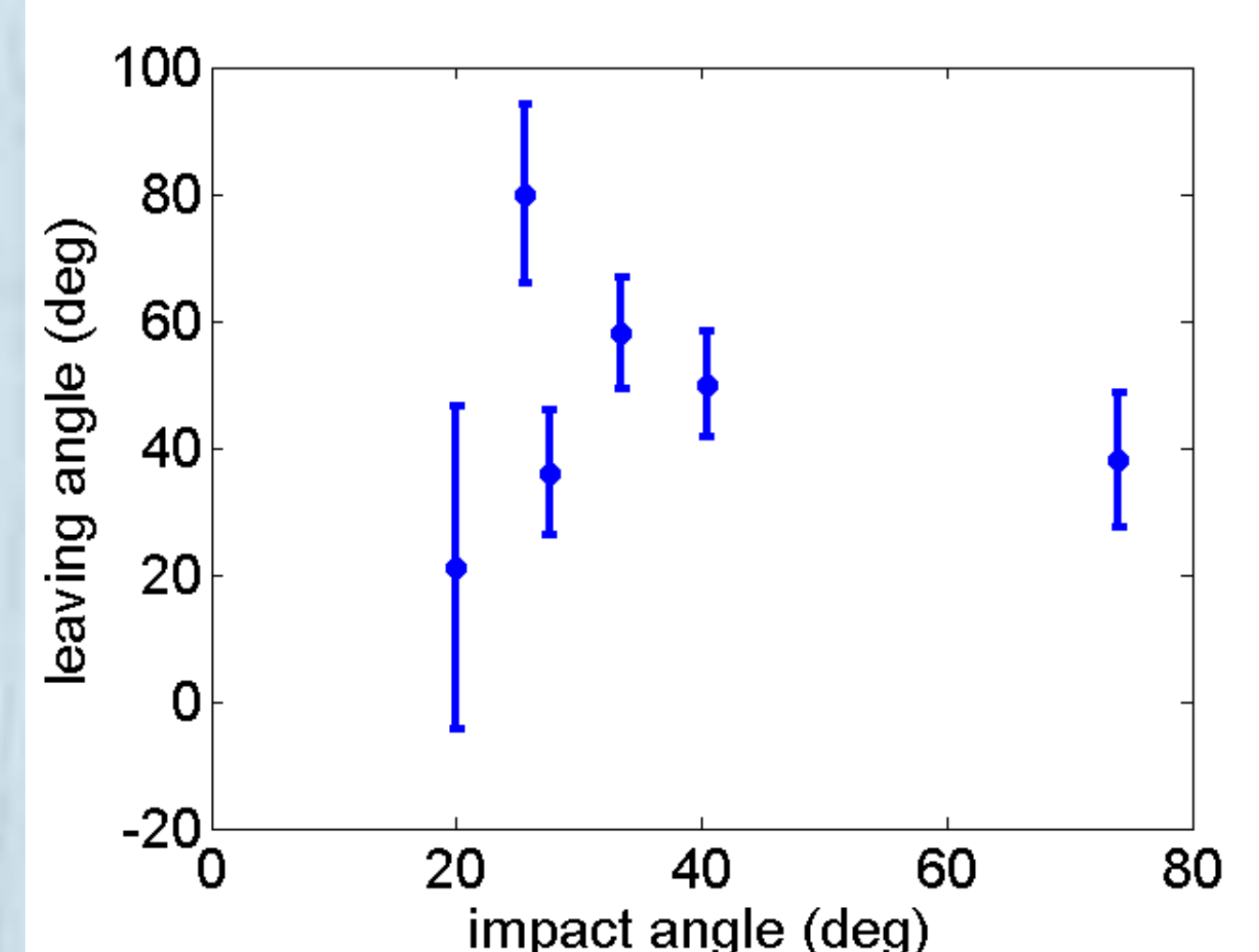
Parameters

- Initial speed at the point of impact- 220, 200, 170, 150 cm/s
- Cylinder material- acrylic, steel, wax paper
- Impact angle- 20~75 deg
- Cylinder diameter
- Faucet bore diameter

Definitions

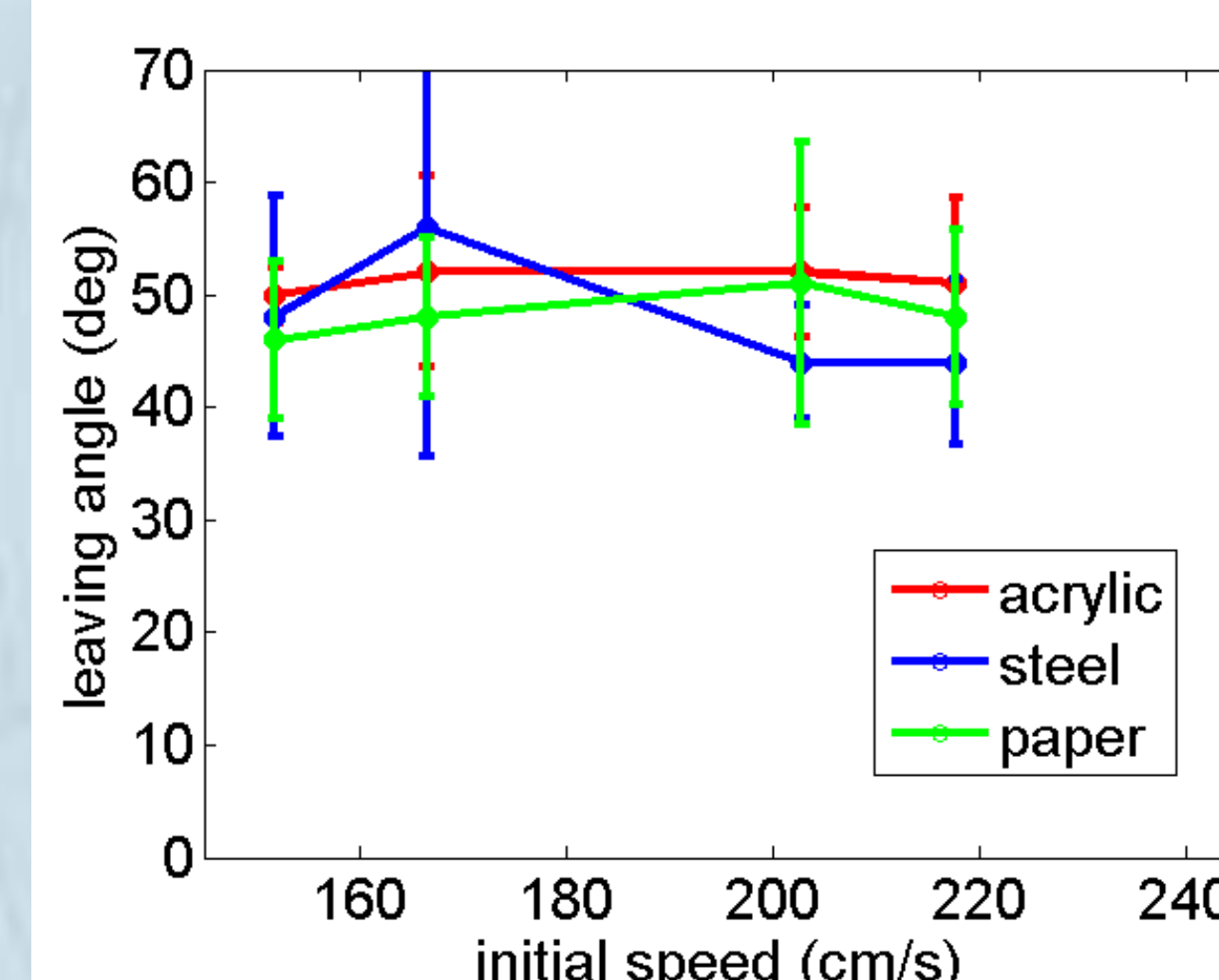


Leaving Angle- Impact Angle



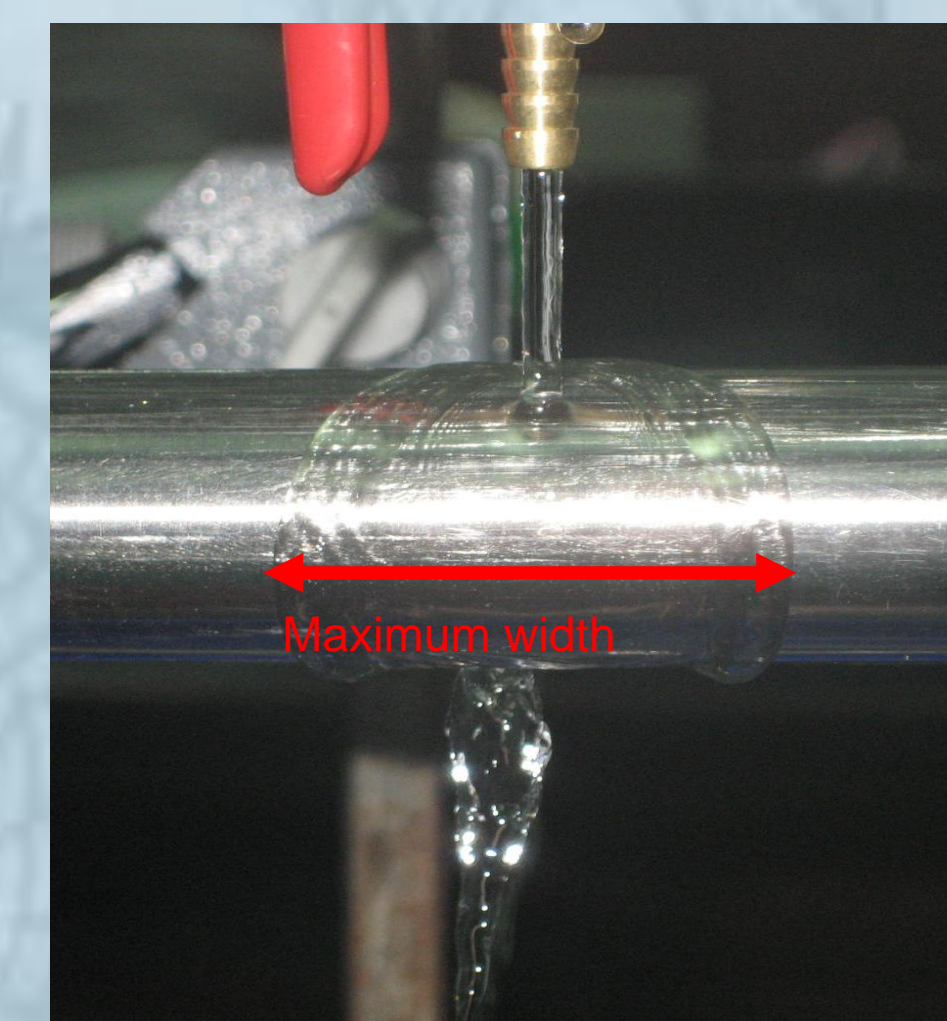
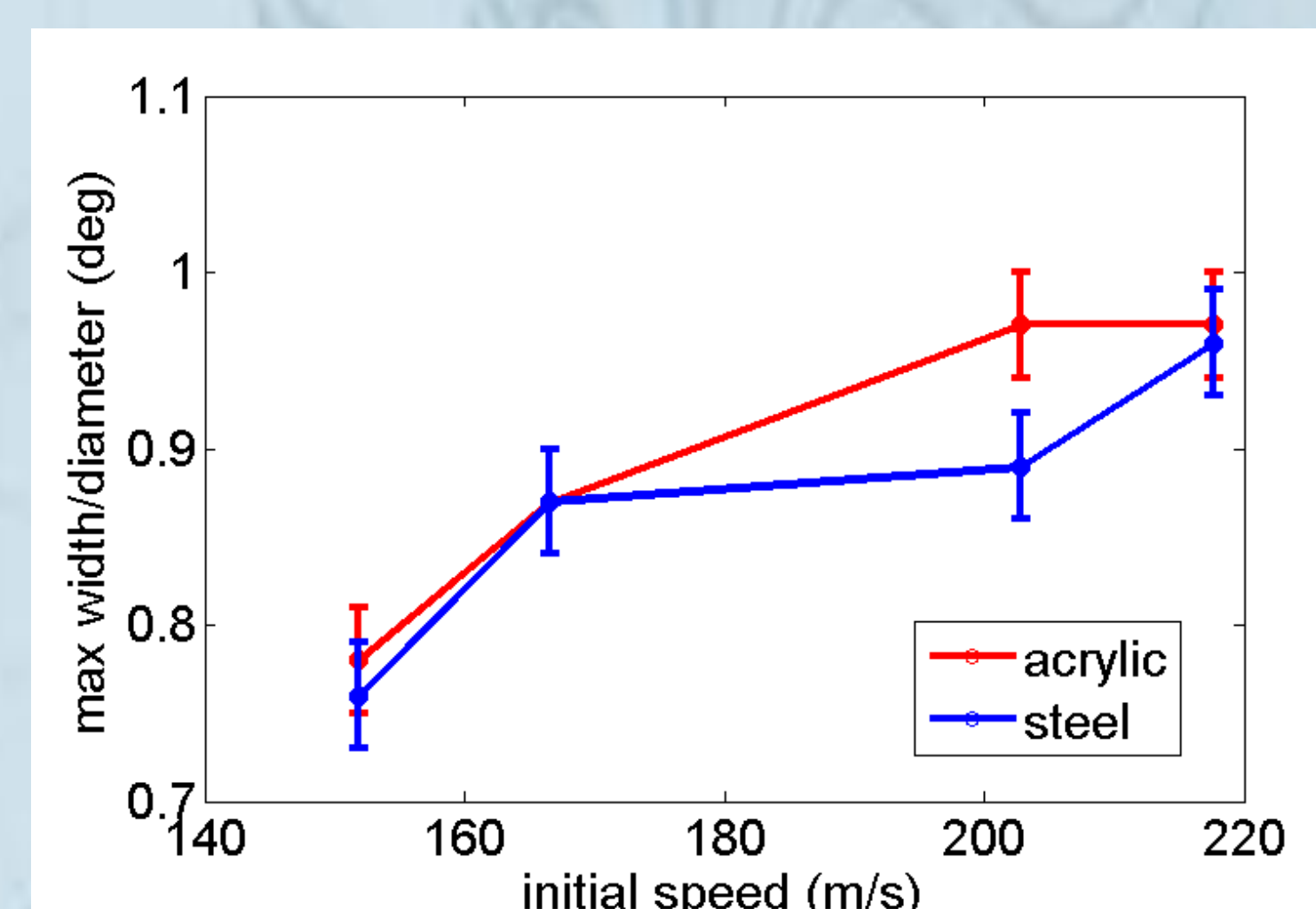
- No significant relation is found.

Leaving angle- Initial speed



- The dependence on the angle is not strongly correlated.
- Material: acrylic

Side Width- Initial Speed



- Higher velocity, larger is the spread.
- Water spreads wider on acrylic cylinder.

Summary

- The “sticky water” effect is real.
- The leaving angle have large error due to instability of the stream. No significant relation is found.
- Stream spreads out when the speed is higher, and wider on acrylic cylinder.

Reference

- Fluid Dynamics for Physicists by T. E. Faber
- Flying Circus of Physics by Jearl Walker
- Fundamentals of Physics by David Halliday, Robert Resnick, Jearl Walker