# Building a Better Droplet Generator: Examination of Brown University Harris Laboratory’s Schematics and Design

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## Abstract

We here present the results of a semester project to assemble a piezoelectric droplet generator to produce millimetric oil drops for use in experimental research of a macroscopic system analogous to Louis de Broglie’s pilot wave theory of quantum mechanics. The 3D-printed droplet generator is an inexpensive alternative to commercially-produced equipment and may be fabricated from readily available components. This droplet generator was constructed according to a design by Dr. Daniel Harris of the Massachusetts Institute of Technology’s Harris Lab. We discuss the function and assembly of the droplet generator and recommend a modification to improve performance and ease of use.

## Background

Approximately fifteen years ago, Yves Couder discovered a macroscopic system which demonstrated quantum-like phenomena through a mechanism reminiscent of Louis de Broglie’s Pilot Wave Theory. This system involves a millimetric oil droplet bouncing across the surface of a vertically vibrating oil bath. The trajectory of the droplet is determined by interactions with the wave field created by its bouncing motion. The oil drop system offers insights toward visualizing and understanding quantum behavior. Producing droplets of repeatable size is necessary to achieving meaningful results, and the 3D-printed piezoelectric droplet generator designed by Dr. Harris is intended as an inexpensive alternative to commercial equipment for droplet production. The objective of this project was to evaluate the 3D-printed droplet generator and determine modifications to improve function.

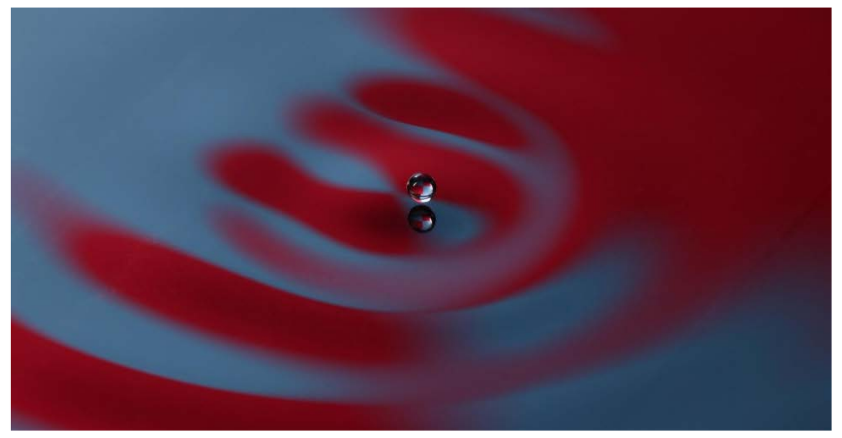

Figure 1. A millimetric oil droplet on a vibrating oil bath (Bush, 2015).

## Design

A Formlabs Form 2 Stereolithography (SLA) 3D printer was used to synthesize structural components of the droplet generator. The piezoelectric component of the generator, controlled by an Arduino Mega microcontroller board, creates a pressure pulse in the fluid chamber of the droplet generator. This high-speed pulse forces one droplet at a time through the nozzle.

- Manual refilling of fluid reservoir via inlet
- Pressure maintained in fluid reservoir via overflow outlet to keep fluid at constant level
- Level of fluid chamber relative to fluid reservoir adjusted to allow flow through connecting tube
- Interior flushed with isopropyl alcohol and deionized water to remove particulates
- Design modified by adding a fluid guide to facilitate proper draining from fluid inlet into reservoir

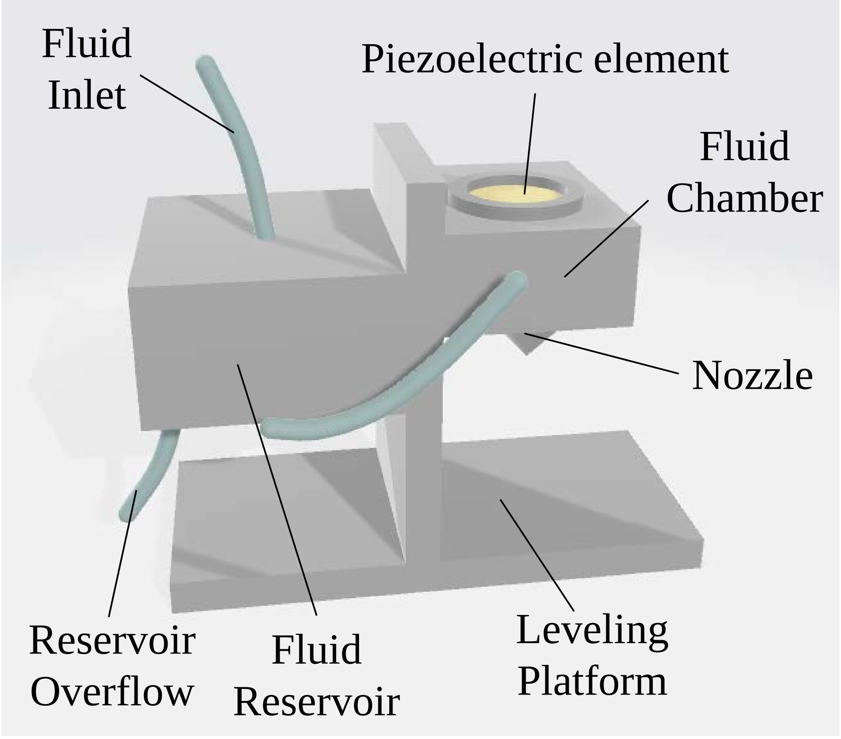


Figure 2. Diagram of primary droplet generator components.

## Construction

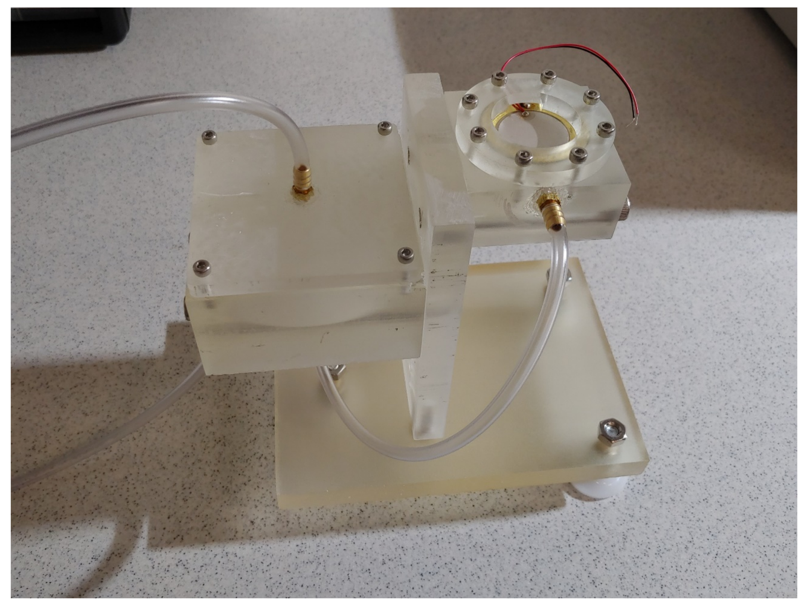

Figure 3. 3D-printed structured of droplet generator plus piezoelectric element and tubing. The structure is mounted on a three-leg leveling platform to minimize introduction of air pockets into fluid chamber. Brass tube fittings are sealed into 3D-printed structural components with silicone sealant.

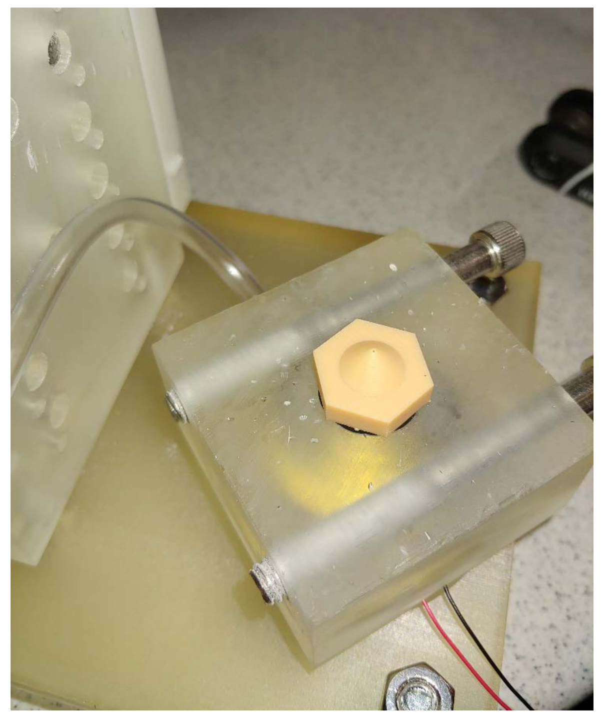

Figure 4. Draining air pockets from fluid chamber. The buildup of air within fluid chamber interferes with transmission of pressure pulse through fluid. Trapped air can be detected by a noticeable change in the tone created by the piezoelectric element’s vibration. The fluid chamber is removed and inverted to release trapped air. O-rings create seals around the piezoelectric element and the nozzle to prevent fluid leakage. Removable nozzles with differing interior widths allow for droplet size selection.

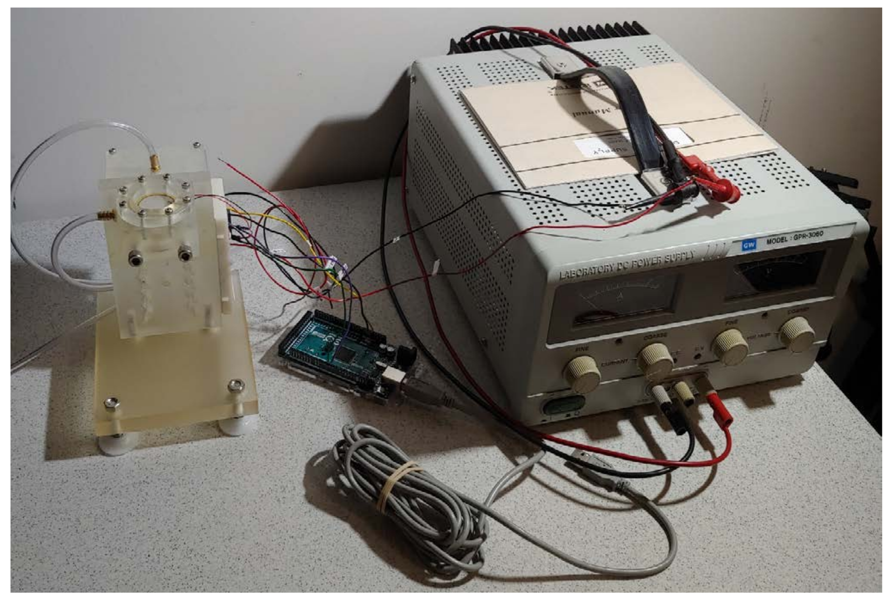

Figure 5. Completed droplet generator setup. A DC power supply and an Arduino Mega are used to power the piezoelectric element and regulate pulse width, respectively. Arduino code can be adjusted to change pulse width and time delay between droplets.

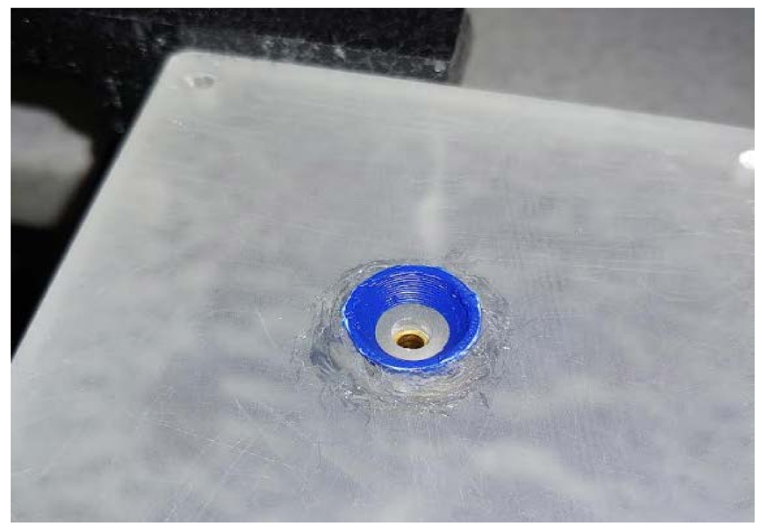

Figure 6. Modification to original design: Fluid guide added to underside of reservoir lid. The inverted funnel shape of the fluid guide prevents liquid from spreading horizontally across the lower surface of the reservoir lid, which caused leaking in initial trials. The fluid guide was printed with an Ultimaker filament 3D printer.

## Results

- Proper droplet production found to be highly sensitive to height difference between reservoir and chamber
- Introduction of fluid guide eliminated leaking of fluid reservoir due to poor draining from inlet

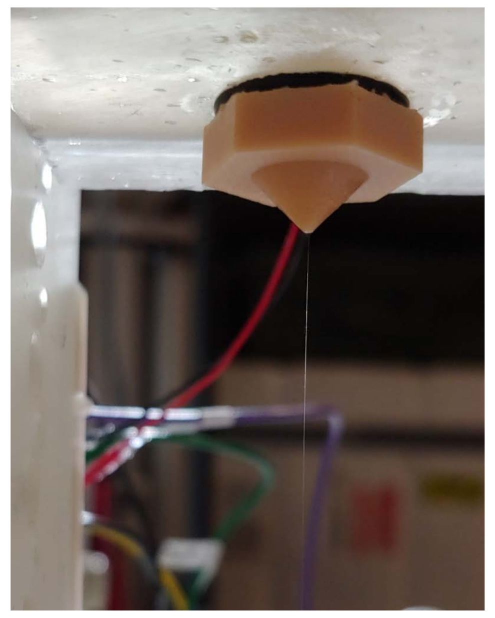

Figure 7. Droplet produced by 3D-printed droplet generator. Droplet appears as a streak due to use of low-speed camera.

## Discussion and Conclusions

The 3D-printed droplet generator design provides a low-cost alternative to commercial products. Preventing air pockets within fluid channels and maintaining pressure by properly selecting the height difference between the reservoir and chamber are essential to ensure consistent droplet production. The introduction of a fluid guide on the underside of the reservoir lid improves the design by preventing fluid leakage. Future steps in this research may include analysis of droplet size consistency, construction of other elements of the walking droplet experimental setup, and experimental research of walking droplet behavior.

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