Millikan oil drop experiment

by Martin Schroedter, Fall 2000

■ Goal

To determine

• the fundamental unit of charge in [C] or [esu].

■ Introduction

The quantization of charge was established by Millikan in 1907 by having his students perform the following experiment many times. A historic account can be found in the red folder in the cubicle.

■ Hints to derive the working equation

• There are several ways to determine the fundamental unit of charge. The most definite answer is gotten by taking lots and lots (30+) of measurements. Consider the following methods:

- measuring the same drop multiple times while changing the charge on the drop by inserting an α-source
- measuring different drops multiple times

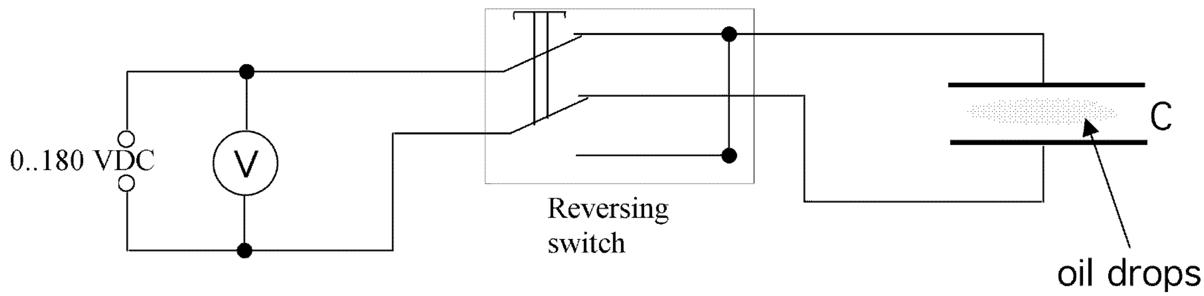
In addition, one has to decide whether to "balance" the drops with electric and gravitational fields, or whether to measure terminal velocity with an arbitrary electric field applied. Again, consider the dis/advantages for both procedures. You are welcome to choose any combination of these procedures or to come up with your own. Y

• The type of working equation you need depends on your chosen procedure. In all cases you need to draw free body diagrams for an oil drop under two conditions:

- free fall
- with electric field applied

• The write-up in *Melissions* contains a complete derivation of one possible procedure and working equation. However, the analysis of the data there is somewhat flaky. The only better way is to measure so many drops that one begins to notice clustering of the measured charge at discret values.

■ Procedure



■ Getting ready

• Draw the set-up and the electrical circuit diagram.

• Calibrate the distance an oil drop would move in the capacitor in terms of what you see on the monitor:
- insert a wire vertically through the top plate
- focus on wire
- lock focus
- remove the top plate of the capacitor and install the little glass scale at the focal point.
- cut a piece off the transparency foil and attach it to the monitor (so you can draw "on" the monitor).
- assemble the capacitor when you are done.

• Measure all external parameters (not drop measurements) that you need in your working equation.

• Produce a sharp image of oil drops on the monitor: You want to illuminate the drops without shining light directly into the camera. To get started, it is easiest to first insert a small wire through the small holes in the top capacitor plate and look at the wire through the telescope with your eyes. Once you can see clearly the dimples in the wire, produce the same image on the monitor. Try out the oil sprayer by spraying in a tissue and make sure you can see and hear when it produces fine mist. A couple of well aimed sprays through the top openings in the capacitor are enough to give you hundreds of drops on the monitor.

■ Measuring drops

• A video recorder is available so you can time the drops "off-line" (especially useful if you are working alone).
• Avoid touching the capacitor plates: > 50 VDC is not pretty to touch!

■ Questions - to be answered in notebook

1. If you ever observed dust in the air you will know that it floats. What is this caused by and how much does it affect the oil drops?

2. What is Brownian motion and what does it depend on (lengths scales, etc.) ?

3. Why is oil used, instead of water ?

4. How is the mass and the diameter of the oil drops determined?

5. Describe the optics.
   - Illumination: lens, yellow filter, etc.
   - Viewing: When do you need the eyepiece in the telescope? What is it for? What are the focal lengths involved?

■ Additional hints

• For guaranteed success do the following before the 1st lab period: *Melissinos* contains data from oil drop measurements and you should try out if you can analyze the data using your own way to determine q_e . Depending on how you want to analyze your data, you may need to take different data.
• Does it matter whether the transparency foil is directly on the monitor or somewhat away from it?