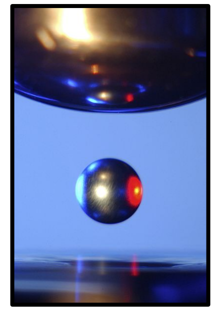
11B Lab 2: **Electrostatic Field Mapping**



This is a close-up of a sample of titanium-zirconium-nickel alloy inside the Electrostatic Levitator (ESL) vacuum chamber at NASA's Marshall Space Flight Center (MSFC). The ESL uses static electricity to suspend an object (about 3-4 mm in diameter) inside a vacuum chamber allowing scientists to record a wide range of physical properties without the sample contacting the container or any instruments, conditions that would alter the readings.

Objective:

1. **Learn how to visualize electric fields and potentials using contour lines and field lines**
2. **Plot contour lines using a digital voltmeter and a sheet of conductive plotting paper**
3. **Understand the mathematical relationship between the electric field and the electric potential**
4. **Learn how to "measure" the electric field using only voltage measurements**

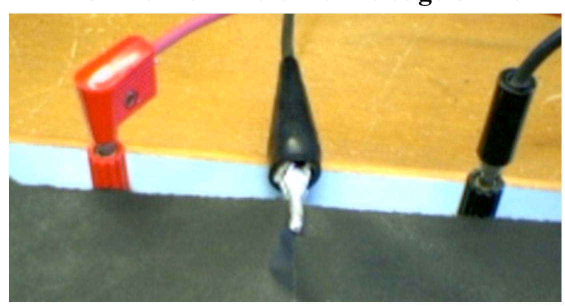
Procedure:

A. **Drawing equipotential contours**
In this part of the lab, you will use a multimeter probe to map out equipotential contours around a pair of electrodes on a sheet of conducting paper.

1. **Set up your potential plotting board and carbon conductive paper**
2. **Place two electrodes on your paper and bolt them into the board tightly. Use either two small circles, or two long bars, so that you get one of the configurations you made predictions for in the pre-lab exercise. If you are using the long bars, each bar should be attached with two bolts, one at either end of the bar.**

3. **Connect the red and black terminals of the board to the DC power supply. Plug in the power supply.**

4. **Using an alligator clip lead, connect the black terminal of the multimeter to the edge of the conducting paper, halfway between the terminals of the board, as in the picture: You will measure all voltages relative to this location.**



5. **Using the red probe of the multimeter, measure the potential of the positive and negative terminals of the board relative to the point halfway in between them where you clipped the alligator lead in the previous part. You should get approximately equal and opposite numbers. If you don't, adjust the position of the alligator clip a little bit to one side or the other to balance them.**

6. **Move the red probe around the sheet of paper to explore the electric potential on the sheet. Make sure the probe is in contact with the sheet, but you do not need to press it very hard (the weight of the probe itself is usually sufficient), and be sure not to drag the probe across the surface. Above all, do not poke a hole through the paper or tear it. (Be especially careful around the places in the board where there is a screw hole beneath the paper surface.) By exploring the sheet with the multimeter probe, you can "map out" the potential in the two-dimensional space you are working in.**

7. **Move the red probe around the sheet until you find a point which gives a reading of half of the voltage of the positive supply. When you find such a point, mark it with the white pencil.**

8. **Move the probe several centimeters away from your previous point and try to find another point at the same potential. Mark it with the pencil. These two points are the beginning of your plot of an equipotential contour at this potential.**

9. Continue in this fashion until your contour either closes in on itself or reaches the edge of the paper. At the places where the contour is highly curved, it will be necessary to take more measurements closer together than in the areas where the contour is fairly straight. Far from the electrodes, you probably only need a point every few inches. The idea is to plot just enough points that you can be fairly sure of the shape of the equipotential contour. If you reach the edge of the sheet before the contour closes in on itself, go back to your original starting point and trace the contour in the opposite direction.

10. Using the white pencil, connect the points you have plotted with a smooth curve, and then label the curve with its potential.

11. Repeat steps 7-9 for contours at every 0.5 volts or so. The main idea is to have enough equipotential lines to create a good overall representation of the electric field.

C. <u>Exploring the electric field</u>

1. In your own word define:

   Electric potential energy
   Electric Potential
   Voltage

2. Define the electric field strength. Discuss the meaning of both the direction and magnitude.

3. Using the red pencil, draw in the electric field lines (discuss this with your TF). Be sure to indicate the direction of the field. If you don't have enough contour lines to make an accurate drawing of the field lines, plot some more.

4. What is the relationship between the orientation of the e-field lines and the equipotential lines? Why?

5. When you reach this point, talk to your TF. Your TF will indicate four points on your sheet where you are to measure the electric field, using the electric field probe.

   Remember, the electric field probe only measures one component of the field. To determine the direction, you can either measure the x- and y-components and then use the equations for vector components, or you can just turn the probe until you get a reading of zero, which occurs when the probe is perpendicular to the field.

6. Does your sketch of field and contour lines correctly indicate the direction of the electric field at the four points?

7. Does your sketch correctly indicate the relative electric field strength at the different points?

8. Unscrew your electrodes and remove the sheet of conducting pape r. Write your names and your lab section time on it, and turn it in to your TF.

Static electricity from this plastic slide causes the child's hair to stand on end. The sliding motion stripped electrons away from the child's body, leaving an excess of positive charges, which repel each other along each strand of hair. (credit: Ken Bosma/Wikimedia Commons)