

# Noise

## Your primary goals for this lab are:

- (1) To understand the physics of Johnson noise, and the close connection between Johnson noise and black body radiation, and to understand how the Johnson noise can be used to measure Boltzmann's constant.
- (2) To understand the physics of Shot noise, and to understand how it can be used to measure the charge of the electron.
- (3) To measure the Johnson noise versus resistance for a series of resistors and to use your measurements to calculate the "quantum of information", which is also known as Boltzmann's constant  $k_B$ . Also to measure the Johnson noise versus temperature (specifically 300 versus 77 Kelvin)
- (4) To measure the Shot noise produced by a temperature-limited vacuum tube diode versus the dc current flowing through the tube, and to use your measurements to determine the "quantum of charge", which is also known as the magnitude of the charge of the electron  $e$ .

**Day One:** Learn how to take data using the spectrum analyzer, and then take Johnson noise data.

**Day Two:** Remember how to take data using the spectrum analyzer, and then take Shot noise data.

**Day Three:** In addition to finishing things that you did not finish on day 1 and day 2, do something creative on the third day. If you have ideas, please run them by me. If you do not, ask me for some. Also, analyze your noise data to make sure it is good. Here good means that your values for  $e$  and  $k_B$  are in reasonable agreement with the literature values. If they are not, retake data as necessary.

## In your lab report:

Explain the physics of Johnson noise  
Explain the close connection between Johnson noise and black body radiation  
Explain how Johnson noise can be used to measure Boltzmann's constant.  
Explain the physics of Shot noise  
Explain how Shot noise can be used to measure the charge of the electron

Analyze your data.  
Plot your measured Johnson noise versus frequency  
Plot your measured Shot noise versus frequency  
Explain how well your values compare to the literature values.