

# AY 105 Lab Experiment #1 explanatory supplement

## The effect of photodiode rotation on measured current

— by Matt Hunt, 2001

When you did Experiment 1, and rotated the photodiode and measured the current as a function of angle, most of you predicted a current profile of  $I/I_0 = \cos \theta$ , but obtained a curve more closely resembling  $I/I_0 = \cos^2 \theta$ . The explanation for this result is more subtle than I expected.

When I discussed the problem with Chuck, he pointed out that we should expect  $I/I_0 = 1$  for small angles. This is because the filament image size is smaller than the detector width, so as you rotate it through a small angle, the entire image should continue to fit on the detector for a while, producing no fall-off in current.

I then discussed the problem with Rob Simcoe, who was the lab TA two years ago. We came to the following conclusions:

Chuck's prediction of no falloff at small angles makes sense in theory, but it is likely that the alignment of the apparatus would be imperfect, resulting in the  $I/I_0 = \cos \theta$  falloff that most of you expected. If the image is a little defocused, or off-center, or the rotational axis is not directly beneath the detector, then the image will start to "fall off" the detector very quickly, and you'll see  $I/I_0 = \cos \theta$ , just as you'd expect if the detector were in, e.g., a collimated beam much larger than itself.

The other issue is that the detector sits behind a glass window which, as some of you noticed, reflects a larger fraction of the incident light as you move toward grazing incidence (large angles off-axis). If you look at, e.g., Jackson's *Introduction to Electrodynamics*, page 367, there is a plot and functional form for the transmitted fraction. This function resembles a cosine, and hence in combination with the above effect can provide the approximately  $\cos^2 \theta$  falloff that you observed.

At large angles, many of you noticed that the detector housing would begin to cast shadows on the detector. This probably has some effect, but at the same time, light begins to fall on the polished walls of the detector housing, and there's probably a lot of scattered light falling on the detector that partially diminishes this effect.