# Lab Report: Estimating Optimal Slit Width for Na Doublet Resolution

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## Introduction

The purpose of this report is to estimate the optimal slit width required to resolve the sodium D-line doublet (centered near 589 nm) using a Czerny-Turner type spectrometer. The resolution goal is to distinguish between the two closely spaced Na lines at approximately 589.0 nm and 589.6 nm. Accurate determination of the slit width is crucial in balancing spectral resolution with light throughput.

## Theoretical Background

The spectral resolution of a grating-based spectrometer is influenced by the width of the entrance slit and the system's dispersion (dλ/dx). The dispersion describes how much the wavelength shifts per unit distance on the detector, typically given in nm/mm or nm/pixel. The narrower the slit, the finer the resolution, but with reduced intensity.

The relationship between the slit width (w), the instrumental resolution (Δλ), and the system's dispersion is:

w = Δλ / (dλ/dx)

Where:  
- w is the slit width in mm  
- Δλ is the desired wavelength resolution  
- dλ/dx is the dispersion of the spectrometer (nm/mm)

## Calculation Example

Assuming the desired resolution is Δλ = 0.6 nm (sufficient to resolve the sodium doublet), and the dispersion of the spectrometer is approximately 2 nm/mm, we can estimate the ideal slit width as follows:

w = 0.6 nm / 2 nm/mm = 0.3 mm = 300 μm

Therefore, a slit width of approximately 300 μm is estimated to be suitable for resolving the Na doublet. For higher resolution, one could use a narrower slit such as 150 μm, at the expense of signal intensity.

## Determining Dispersion

If the dispersion is not known, it can be estimated using known spectral features and their separation on the detector. For example, if two known lines 10 nm apart are found to be 5 mm apart on the detector, then:

dλ/dx = 10 nm / 5 mm = 2 nm/mm

Alternatively, if using a digital camera or CCD with known pixel size, dispersion can be approximated by:

dλ/dx = Bandwidth / (pixels × pixel size in mm)

## Conclusion

The estimated slit width required to resolve the sodium doublet using a Czerny-Turner spectrometer is approximately 300 μm, assuming a dispersion of 2 nm/mm. For enhanced resolution, smaller slits can be used if light levels allow. Accurate dispersion calibration is essential for optimizing this estimation.