# Lab Report: Uncertainty in Slit Width Measurement for Spectrometer Resolution

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## Introduction

In this report, we estimate the uncertainty involved in measuring the slit width for a spectrometer setup. The slit width is crucial for resolving spectral lines, and in this case, we are focusing on the sodium D-line doublet, located at approximately 589.0 nm and 589.6 nm. Accurate measurement of the slit width is vital for achieving the desired spectral resolution, and this report will assess the effect of measurement uncertainty on the ability to resolve this doublet.

## Theory of Uncertainty

When using a measuring tool with finite resolution, there is an associated uncertainty in the measurement. For example, a tool with a resolution of 0.5 mm means that any measurement made with the tool could vary by ±0.25 mm, since the smallest unit the tool can measure is 0.5 mm. This uncertainty is crucial for interpreting experimental results, especially when precision is required, such as in the case of determining the slit width for resolving closely spaced spectral lines.

## Given Information

In our case, we are using a measuring tool with a resolution of 0.5 mm to determine the slit width. We aim to measure the slit width that would allow us to resolve the sodium D-line doublet, which is approximately 589.0 nm and 589.6 nm apart, with a target resolution of 0.6 nm. The spectrometer dispersion is assumed to be 2 nm/mm, and we have previously estimated that the required slit width for this resolution is around 0.3 mm.

## Uncertainty Calculation

The uncertainty in measuring the slit width is determined by the resolution of the tool. Since the tool has a resolution of 0.5 mm, the uncertainty in the measurement is taken as ± half the smallest unit of measurement. This gives an uncertainty of ±0.25 mm.

Now, we calculate the uncertainty in the slit width measurement using the following relationship:

δw = ± 0.5 mm / 2 = ± 0.25 mm

Thus, the uncertainty in the slit width measurement is ±0.25 mm. If we measure the slit width to be 0.3 mm, this means the actual slit width could vary between 0.05 mm and 0.55 mm. This range represents a significant uncertainty compared to the target slit width of 0.3 mm.

## Impact on Spectral Resolution

The large uncertainty in slit width measurements has important implications for the spectrometer's ability to resolve spectral lines. For example, if the slit width is measured as 0.3 mm but can vary by ±0.25 mm, the actual slit width could be between 0.05 mm and 0.55 mm. This level of uncertainty is large compared to the required precision for resolving the sodium D-line doublet, which is separated by just 0.6 nm.

Therefore, achieving the necessary resolution with this measuring tool would be challenging, as the uncertainty in the slit width measurement exceeds the precision required to resolve the spectral lines. To achieve better precision, a tool with a smaller resolution, such as a micrometer or a digital caliper, would be needed.

## Conclusion

In conclusion, the uncertainty in measuring the slit width with a tool that has a resolution of 0.5 mm is significant enough to prevent precise determination of the slit width needed to resolve the sodium D-line doublet. With an uncertainty of ±0.25 mm, the measurement could vary considerably from the target slit width of 0.3 mm, making it unsuitable for high-precision spectroscopic measurements. A more precise measuring tool is recommended for accurate determination of the slit width in this application.