Spectral Imaging Experiment: Na-Doublet with Czerny-Turner Spectrometer

# Abstract

This document presents an overview of an experiment designed to study the spectral properties of the sodium (Na) doublet using a Czerny-Turner type spectrometer. The primary focus is on the identification and analysis of the sodium D-lines, specifically the D1 (589.6 nm) and D2 (589.0 nm) lines, through spectral imaging. The experiment aims to understand quantum defects, spectral line characteristics, and the principles of atomic transitions in sodium, with the theoretical background drawn from atomic physics principles.

# Theory

The sodium D-lines (D1 and D2) result from electronic transitions between the 3s and 3p energy levels of sodium atoms. The D1 line corresponds to the transition from 3p\_3/2 to 3s\_1/2, and the D2 line corresponds to the transition from 3p\_1/2 to 3s\_1/2. These transitions are influenced by factors such as quantum defects, which refer to the deviation of observed energies from theoretical predictions based on the hydrogen atom model. The Czerny-Turner spectrometer is used to capture the emitted light from a sodium discharge, enabling precise measurement of the spectral lines. This type of spectrometer relies on a diffraction grating to separate light into its component wavelengths for analysis.

# Experiment Setup

The experiment utilizes a Czerny-Turner type spectrometer to study the spectral lines of sodium. The key components include a sodium discharge lamp as the light source, a diffraction grating to separate the wavelengths, and a detector to capture the spectral image. The spectrometer is aligned to resolve the sodium D-lines, with an emphasis on minimizing aberrations and ensuring proper calibration. The spectrometer is adjusted to accurately measure the wavelengths of the D1 and D2 lines.

# Data Analysis

The recorded spectral image is processed to extract the positions of the sodium D-lines. The wavelengths are compared to known values, and any deviations are analyzed to assess quantum defects. The analysis also focuses on understanding the factors that may cause slight shifts in the observed wavelengths, including instrumental effects and atomic interactions. The theoretical predictions of the sodium D-lines are also considered in this analysis.

# Conclusion

The experiment provides valuable insights into the spectral properties of sodium, particularly the D-lines. By analyzing the data from the Czerny-Turner spectrometer, it is possible to explore the effects of quantum defects on the sodium lines and deepen our understanding of atomic transitions. The experimental setup and analysis approach demonstrate how spectrometric tools can be effectively used in atomic physics research.

# References

Tennyson, Jonathan. (Year). Title of the referenced work. Publisher.