

Simulation and optical design of a compact high-resolution spectrograph using Zemax OpticStudio

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This research focuses on the optical design and simulation of a high-resolution spectrograph. Spectrographs are extremely useful in astronomy. By analyzing the spectrum, we can determine the physical and chemical composition of celestial bodies for various research purposes. Astronomical spectrographs are typically mounted at the eyepiece of the telescope. However, Cassegrain telescopes with Alt-Azimuth mounts, which are comparatively inexpensive and widely used by astronomers, do not allow a commercially available spectrograph to be mounted at the eyepiece due to the limited gap between the telescope and the mount. Therefore, a new compact high resolution spectrograph is designed which can be coupled directly to these types of telescopes. The overall resolving power of a spectrograph is a key parameter of astronomical observations. Therefore, we focused on maximizing the resolving power and introduced concave lens in between the slit and the collimator, which increases the optical beam incident on the diffraction grating. The optical design and simulations were conducted using a widely used optical modeling tool, Zemax OpticStudio. The main objective of this design is to determine and validate the performance and measurements required for the physical construction of the spectrograph to achieve maximum resolution. Essential components such as the entrance slit, collimating and focusing lenses, diffraction grating, and spacing between components were precisely calculated. These calculated values were then compared with simulation results to verify their accuracy and performance. Validation was performed through spot diagram analysis. The system demonstrated distinct wavelength separation for 400 nm, 550 nm, and 700 nm with minimal vertical spread, indicating accurate slit imaging and good focus across the visible spectrum.

Keywords: *Spectrograph, Alt-Azimuth mount, Optical design, Zemax OpticStudio, Astronomy instrumentation*

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