CTA200H 2021 final project

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Introduction

My project will involve learning about the mechanics and calibration of digital micro-mirror device multi-object spectrographs (DMD-MOS). The goal of this assignment is to introduce me to a few basic long-slit grating spectroscopy concepts.

Key equations

The first important equation to understand is the grating equation, where m the groove number, d is the groove separation, λ is wavelength, α is incident angle and β is diffraction angle.

$$m\lambda = d(sin\alpha + sin\beta) \tag{1}$$

Using the grating equation, the angular dispersion can be calculated by taking the derivative of β with respect to λ

$$\frac{d\beta}{d\lambda} = \frac{m}{d\cos(\beta)} \tag{2}$$

Similarly, linear dispersion can be found by multiplying angular dispersion by the focal length

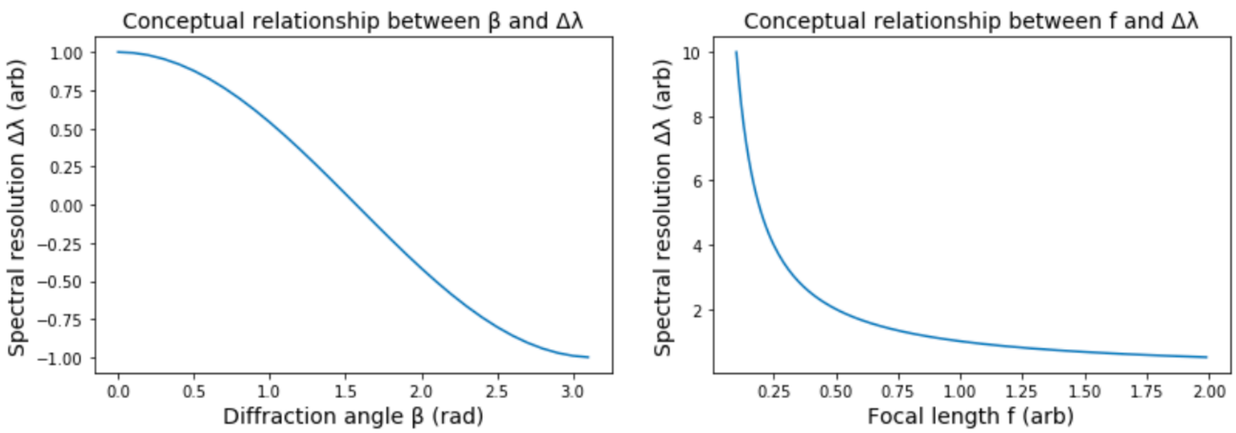
$$\frac{dx}{d\lambda} = f\frac{d\beta}{d\lambda} = \frac{fm}{d\cos(\beta)} \tag{3}$$

Setting p as pixel pitch (approximtely equal to pixel width) and assuming each diffracted spectrum spans 2 pixels, the spectral resolution $\Delta\lambda$ can be calculated as follows (derived based on http://irtfweb.ifa.hawaii.edu/ cushing/downloads/Spectroscopy.pdf)

$$\Delta\lambda = \frac{2p}{f}\frac{d\lambda}{d\beta} = \frac{2p}{f}\frac{d\cos(\beta)}{m} \tag{4}$$

Relationships

Using equation 4, the conceptual variation of $\Delta\lambda$ with respect to β and f respectively can be visualized. I did this by holding all other variables constant (equal to 1) in each case, and plotting the result using matplotlib. As the figure below shows, we see a typical cosine dropoff wrt β, and an inverse relationship wrt f.



Afterword

While this is only a sample of the questions provided by my supervisor, I will complete the rest outside of this assignment. Thank you for all your help throughout this course!