Long Slit Spectrograph using Asymmetric Offner

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Abstract

A spectrograph is assembled using an asymmetric Offner relay. The design of the Offner relay allows for a pupil, where a grating is placed. The design of the spectrograph uses commercially available parts and makes use of 3D printing in order to lower costs and raise availability. It is designed to be mounted on the C14 Celestron at the Physics and Astronomy Teaching Observatory.

Introduction and Motivation

Spectrographs are a powerful tool for astronomers. They split the incoming light across its component wavelengths, allowing astronomers to study features that may appear at certain wavelengths.

Inside instruments, light must be moved around to reach the detector, while trying to deform it as little as possible. One of the ways to do this is with something called an Offner relay. The Offner relay makes use of the characteristics of spherical mirrors to transport the light with minimal aberrations. Generally, an Offner relay consists of two spherical mirrors, one convex and one concave, with the radius of curvature of the concave one being twice that of the convex. A typical Offner relay is depicted in Figure 1A.

However, Offner relays can also be asymmetric (Figure 1B), a fact which was recently noted[1]. When Offner relays are asymmetric, they can form an accessible pupil, a place where all the light passes through and is free from confusion of other light rays. This property is useful for a variety of reasons. One is that you can place a filter or anything else for the light to pass through in the pupil, and its size will be relatively constrained.

The goal of this project is to create a spectrograph using an asymmetric Offner relay, with the relay made of commercially available, and thus cheaper, parts. This promotes accessibility and reproducibility of astronomy research.

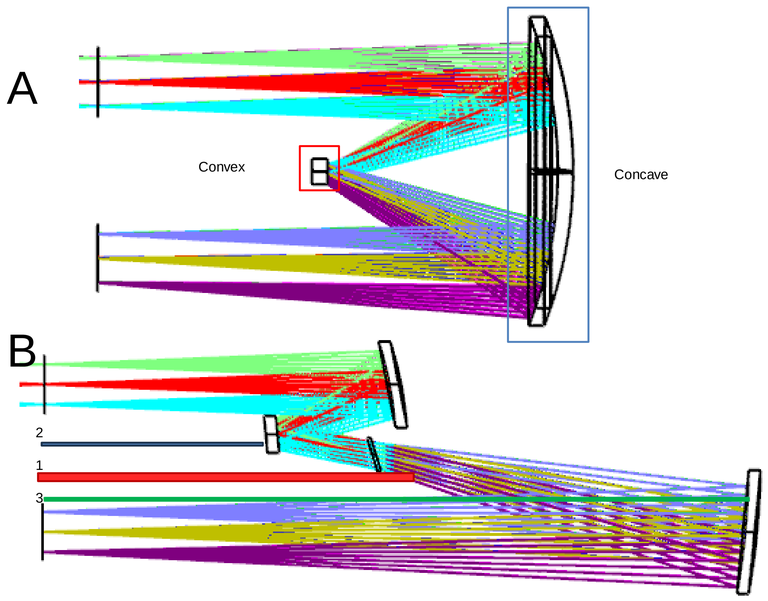
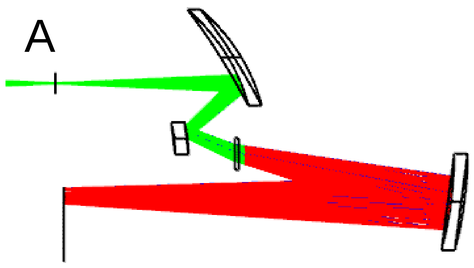
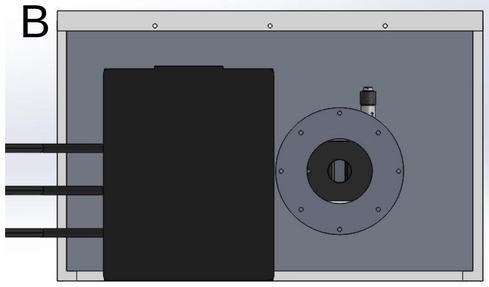


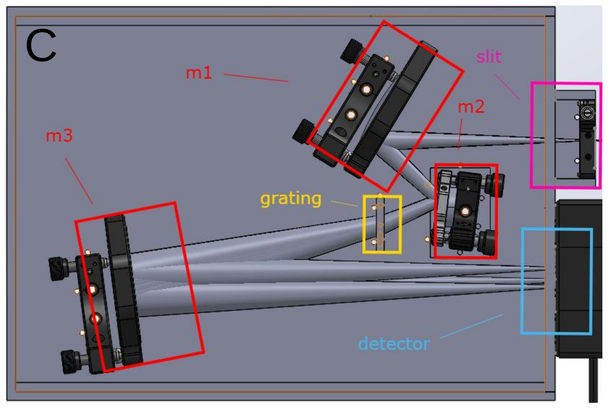
Figure 1.
A. A typical Offner relay which has two mirrors, with convex (red) RoC = ½ concave (blue) RoC
B. An asymmetric Offner relay, where the pupil is marked by a black line. RoC calculated by equation given in Reference (r3 = r2r1/(r1-r2)).

Reference

1: Rakich, Andrew ; Rogers, John R. "A generalized Offner relay with an accessible pupil" December 2020







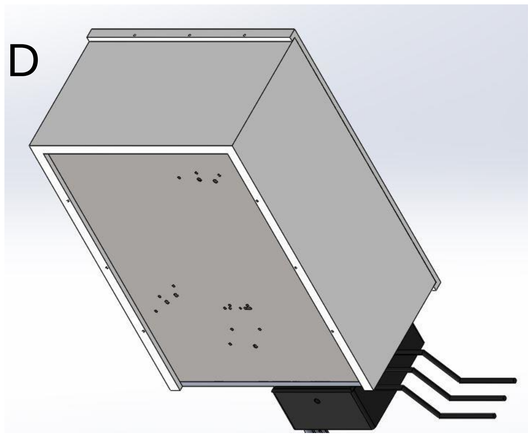


Figure 2.
A. The ray tracing of the optical design in Zemax Optic Studio
B. The front of the spectrograph, facing the detector and telescope interface
C. The top view of the spectrograph with the cover removed, with mirror mounts, grating mount, detector and slit
D. An isometric view of the case from the bottom

Design Components

Part	Description	Part #	Company
m1	150 mm radius of curvature concave spherical mirror	CM750-075-F01	Thorlabs
m2	100 mm radius of curvature convex spherical mirror	#87-657	Edmund Optics
m3	300 mm radius of curvature concave spherical mirror	CM750-150-F01	Thorlabs
Mirror Fixture 1	2 x KS3 mirror mounts	KS3	Thorlabs
Mirror Fixture 2	1 x KS1 mirror mount	KS1	Thorlabs
Grating	300 lines/mm grating	#49-579	Edmund Optics
Slit	VA100 Slit	VA100	Thorlabs
Detector	CCD Detector	ST-8300	SBIG

Discussion

The parts which cannot be purchased are the four-part case, the grating mount, slit mount, and the telescope interface.

Though this design is not finalized, once it is, it will be built, and used at the TAMU Teaching Observatory (Figure 3).

Figure 3. TAMU Teaching Observatory

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