Today: Spectrograph Basics

Reading: Ch. 12

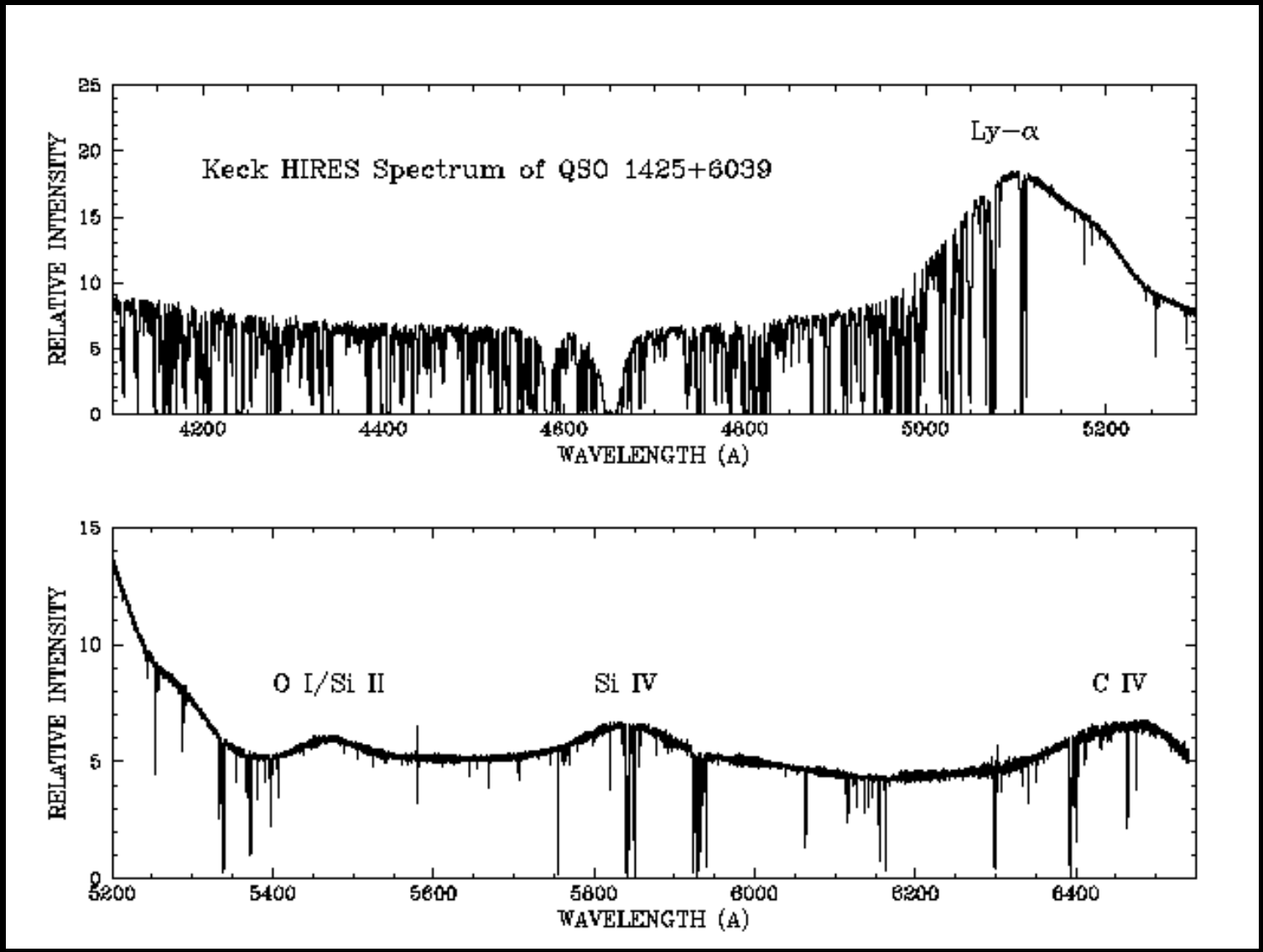
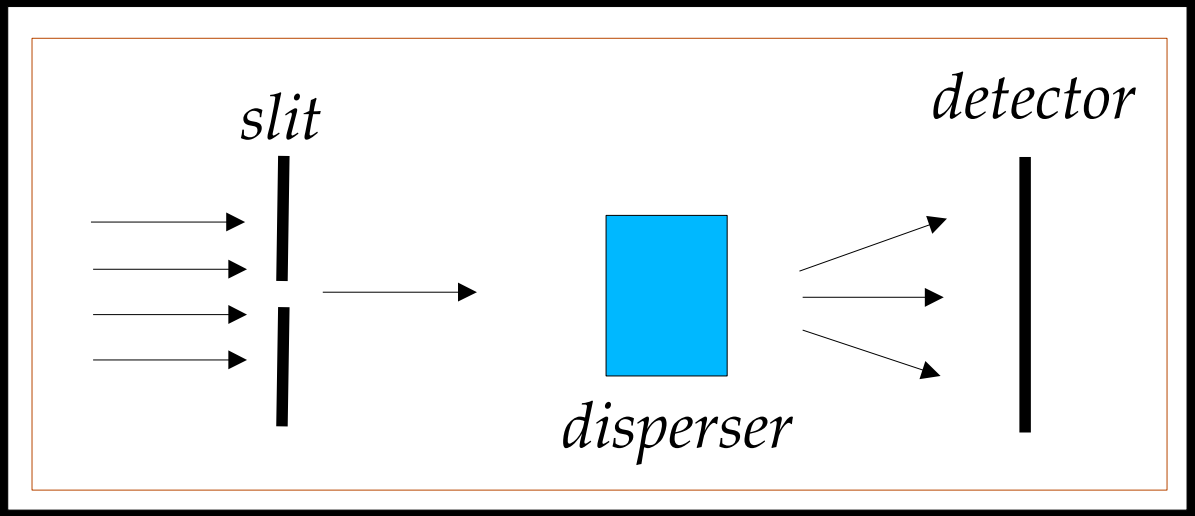


Image Credit: Wallace Sargent

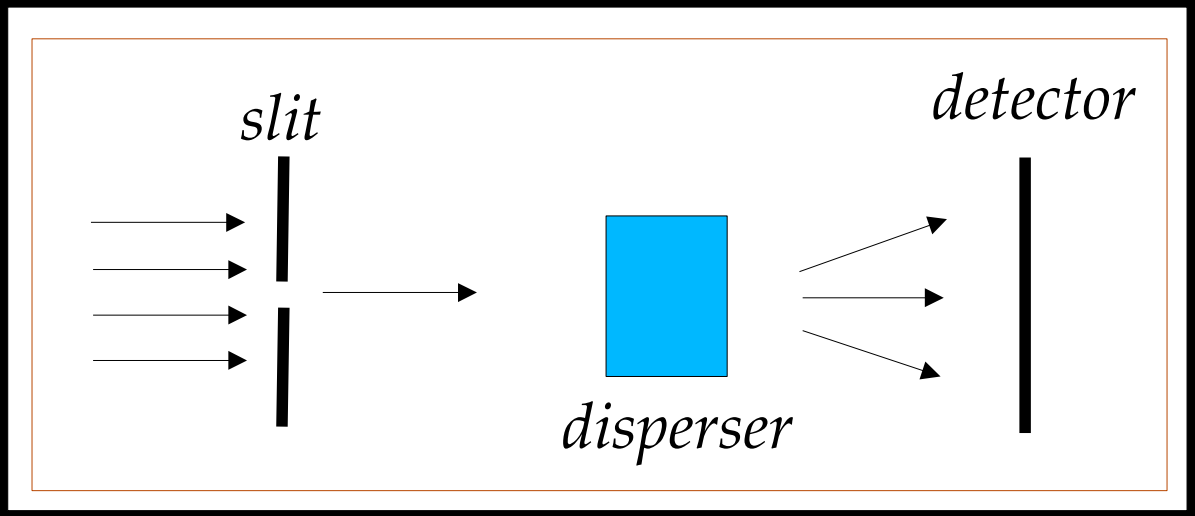
Basic Spectrograph Design



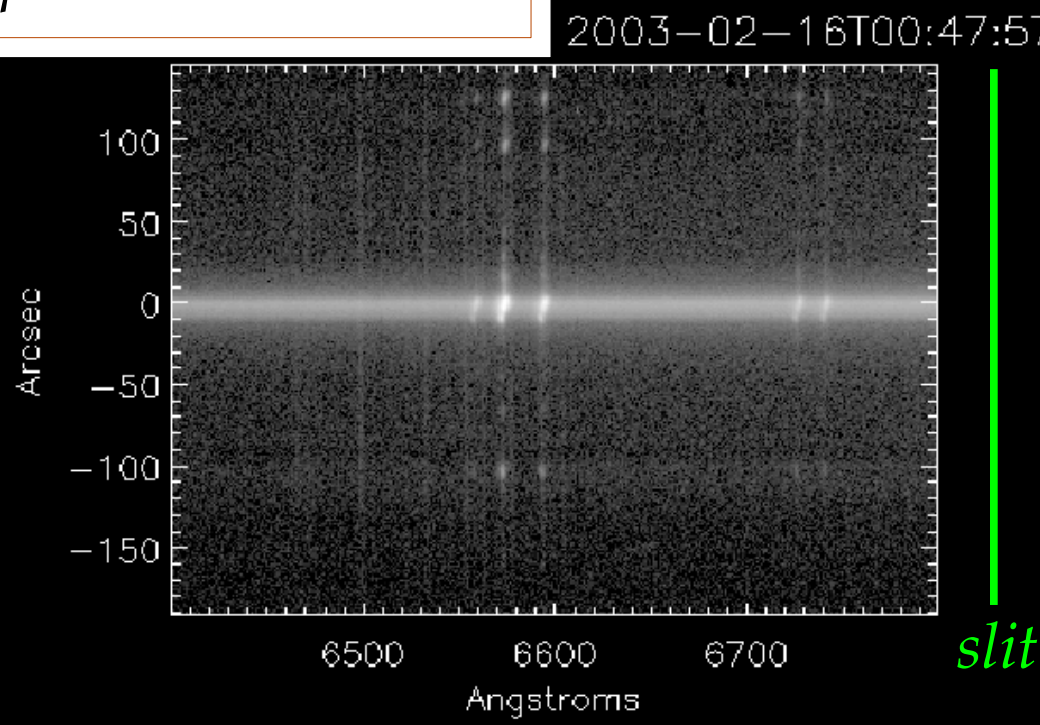
Types of dispersers:

- Prism
- Grating
- Grism
- Interferometer

Basic Spectrograph Design



A CCD records a 2-D image with position along the slit perpendicular to the dispersion axis.



Combined Image and Grism Spectrum of SN1987A

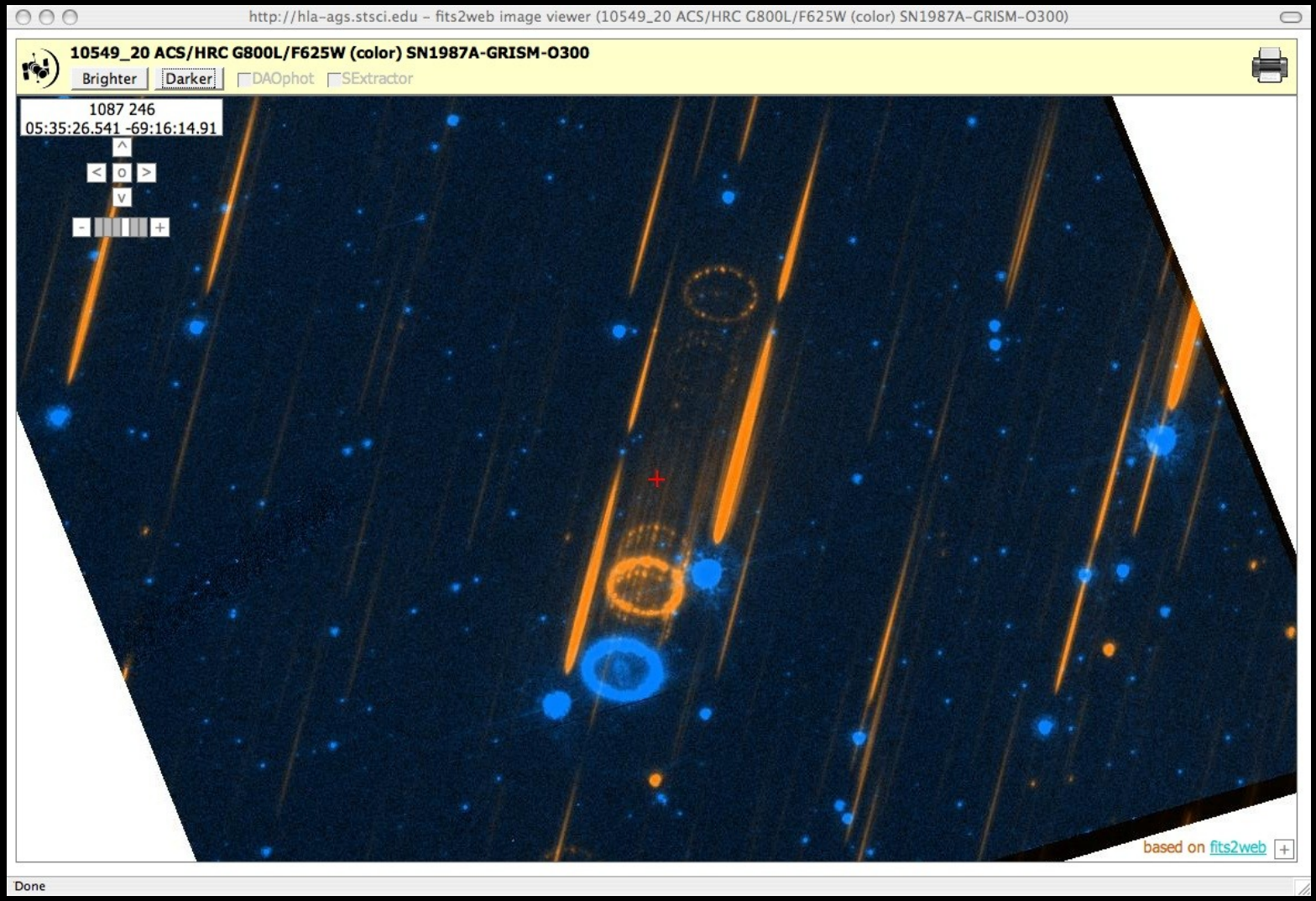
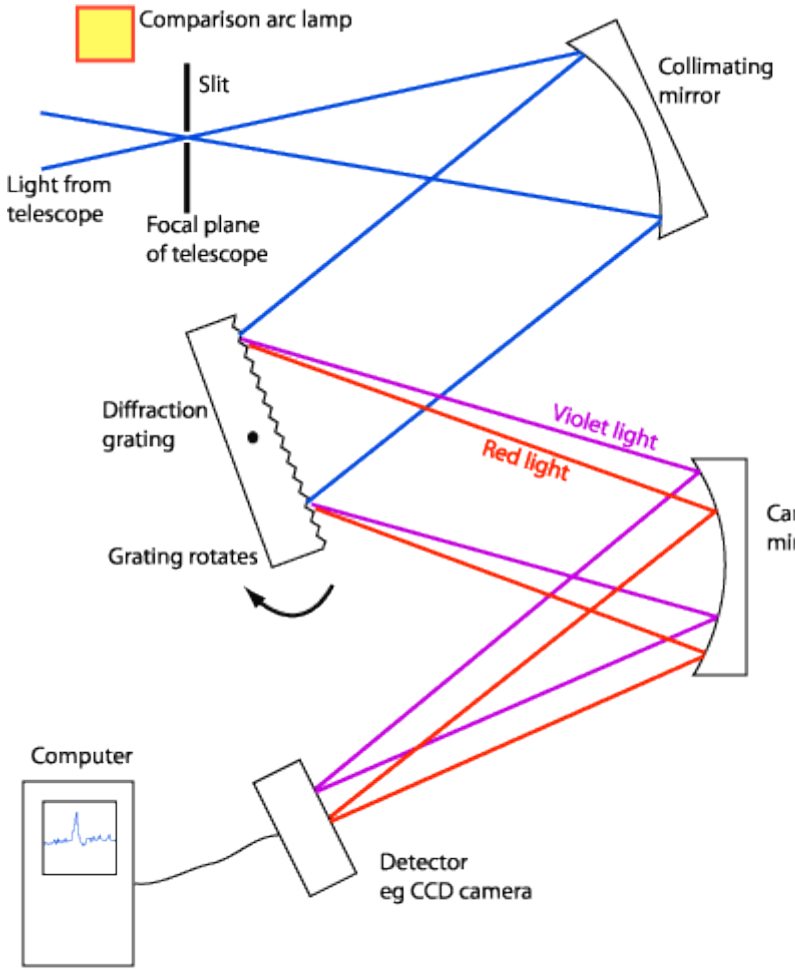


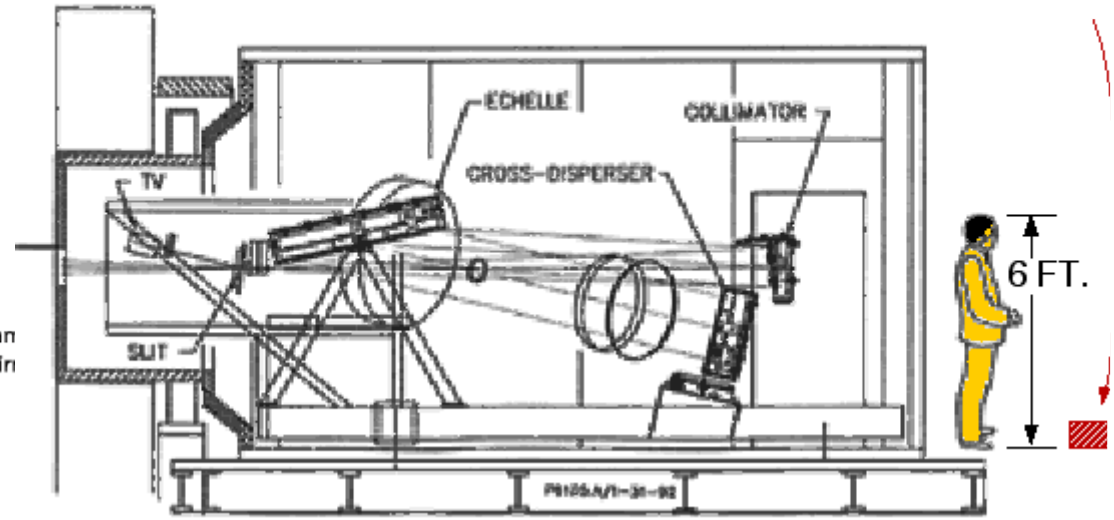
Image Credit: STSCI



A Schematic Diagram of a Slit Spectrograph

Credit: Adapted from a diagram by James B. Kaler, in "Stars and their Spectra," Cambridge University Press, 1989.

Keck spectrometer (HIRES)
$4 million, 8 tons, 5 m length



Multiple Object Spectroscopy

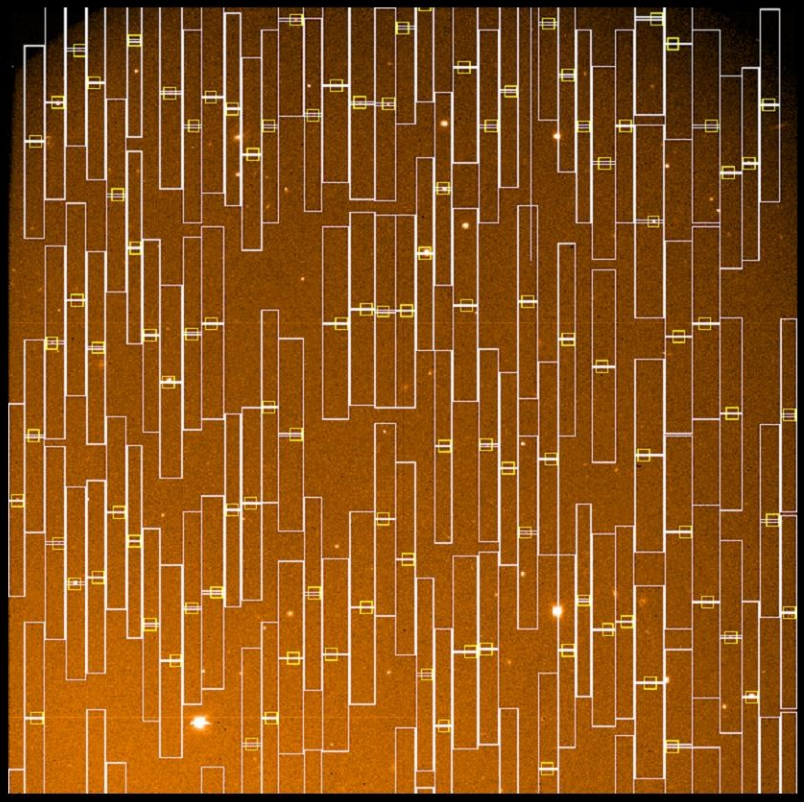
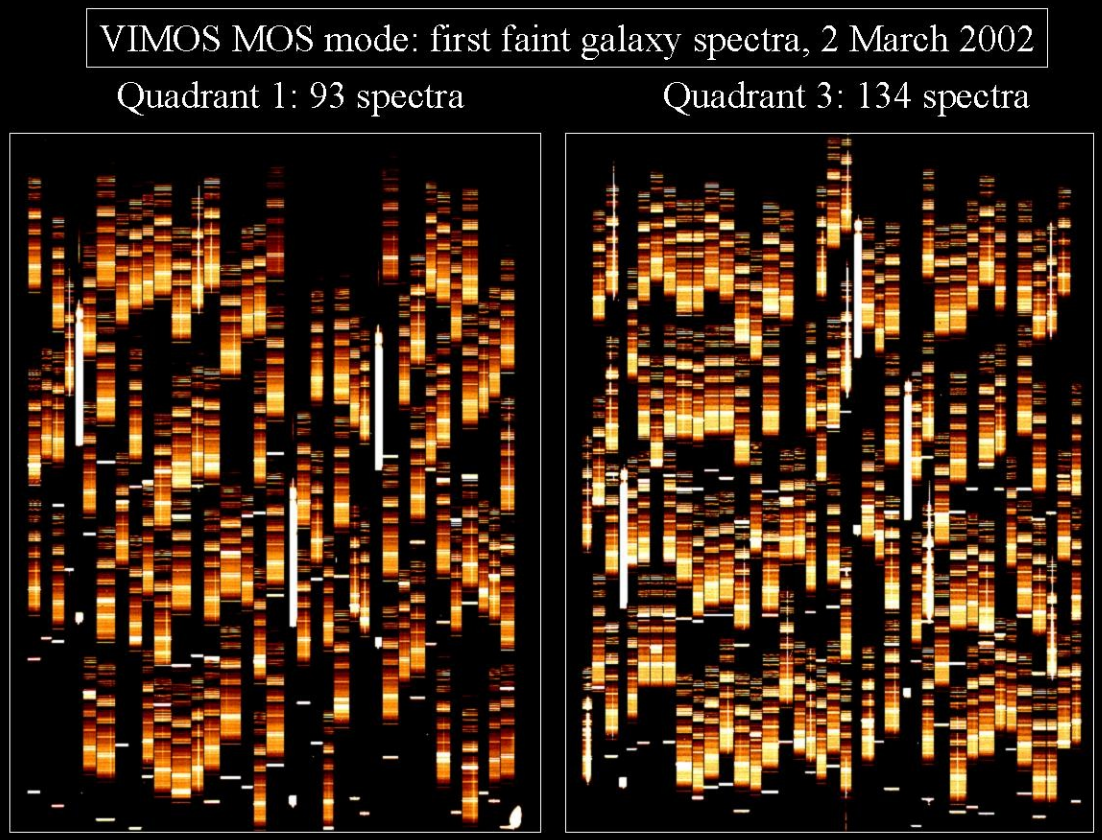


Image credit: ESO

Mask design for VIMOS (Visible Imager and Multi-Object Spectrograph).



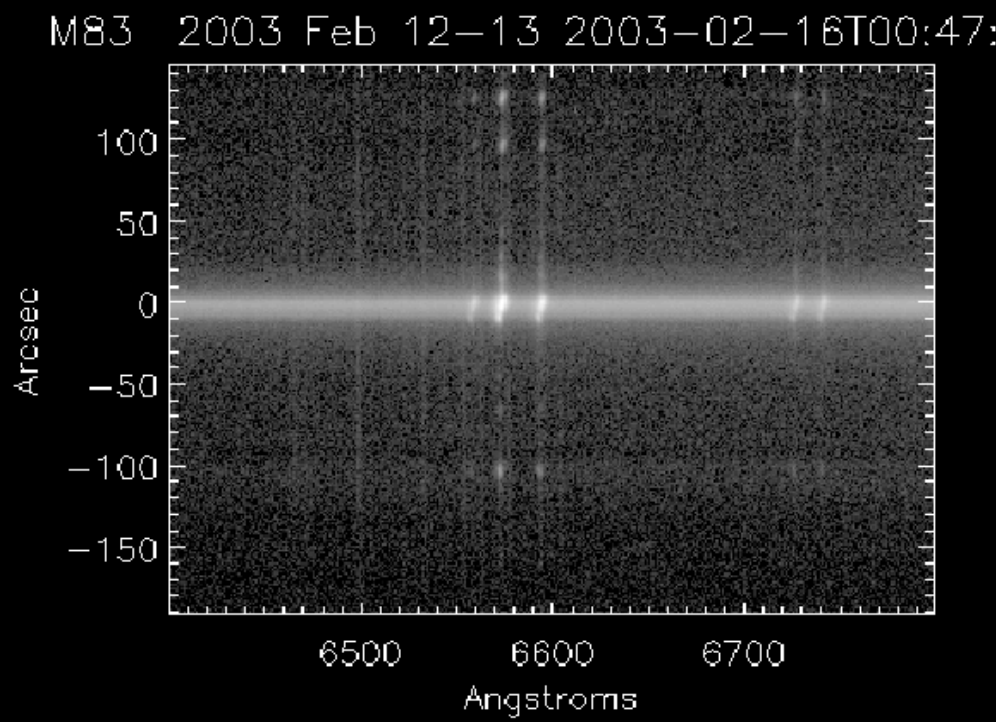
Spectrograph Properties

Linear dispersion: $\frac{d\lambda}{dx}$ or $\frac{dx}{d\lambda}$

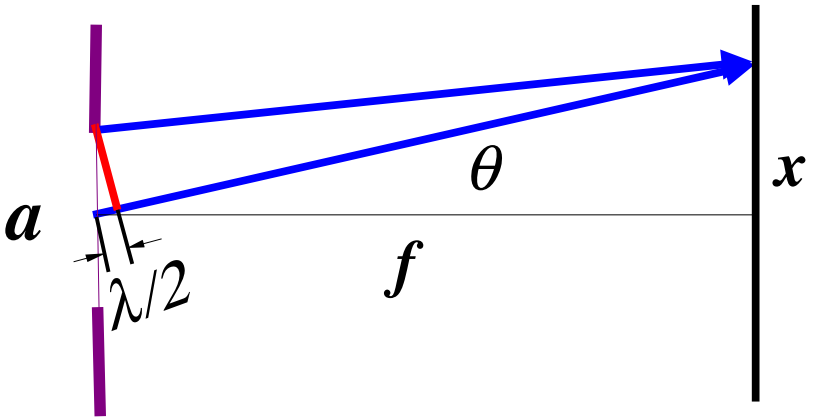
Resolving power: $R = \frac{\lambda}{W_\lambda}$

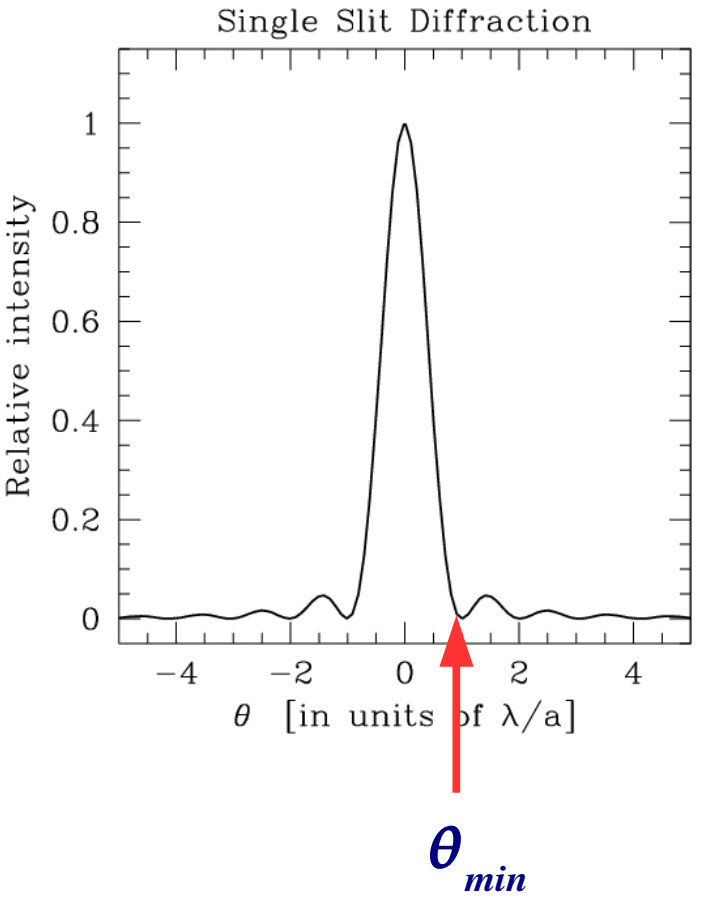
where $W_\lambda = W \cdot \frac{d\lambda}{dx}$

and W is the physical size of the point source image in the detector plane.



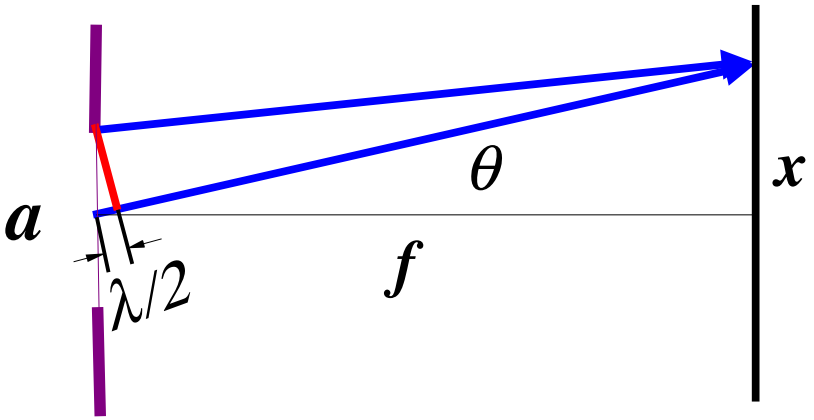
Spectrum Formation in a Grating Spectrometer

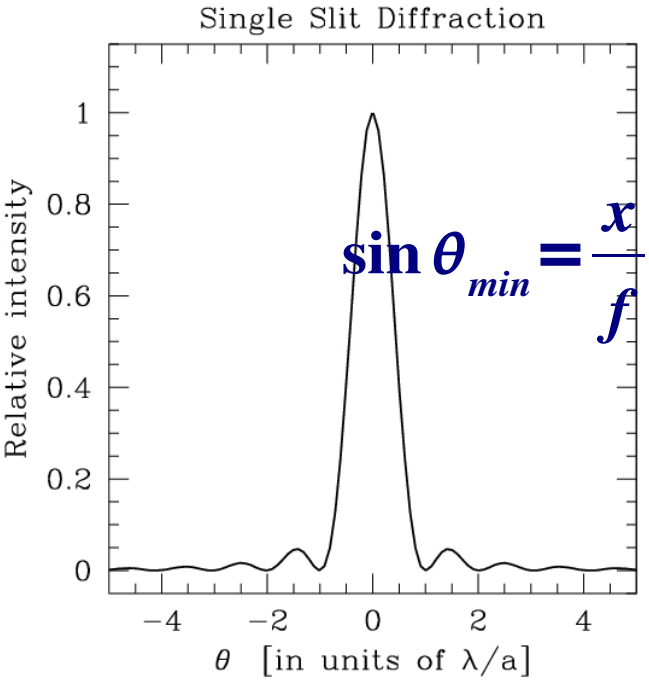




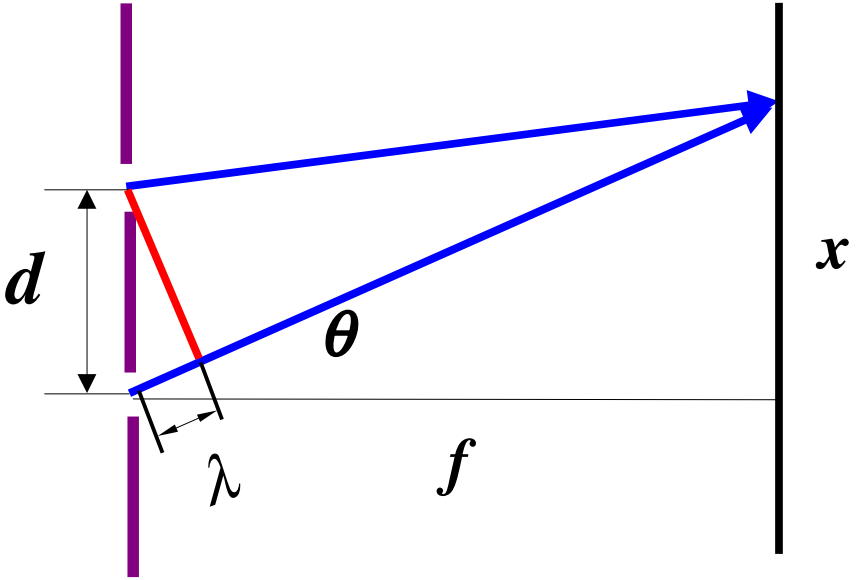
$$\sin\theta_{min} = \frac{x}{f} = \frac{\lambda}{a}$$

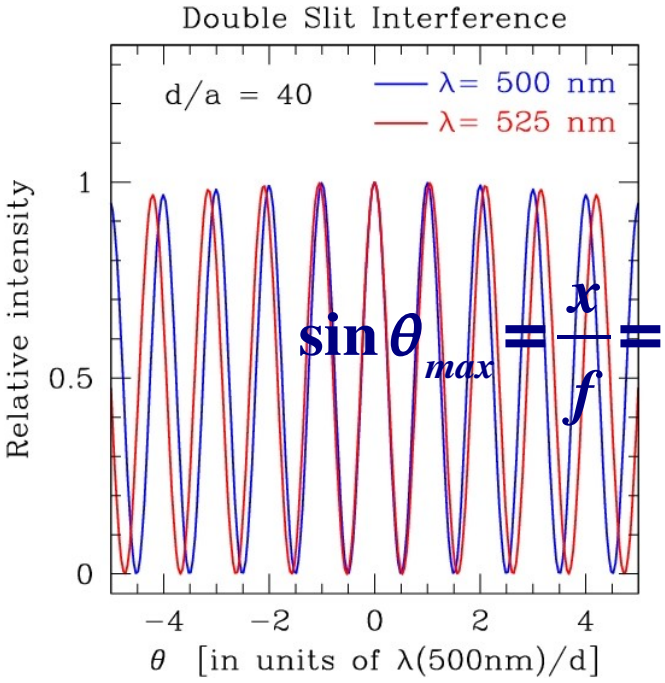
Spectrum Formation in a Grating Spectrometer





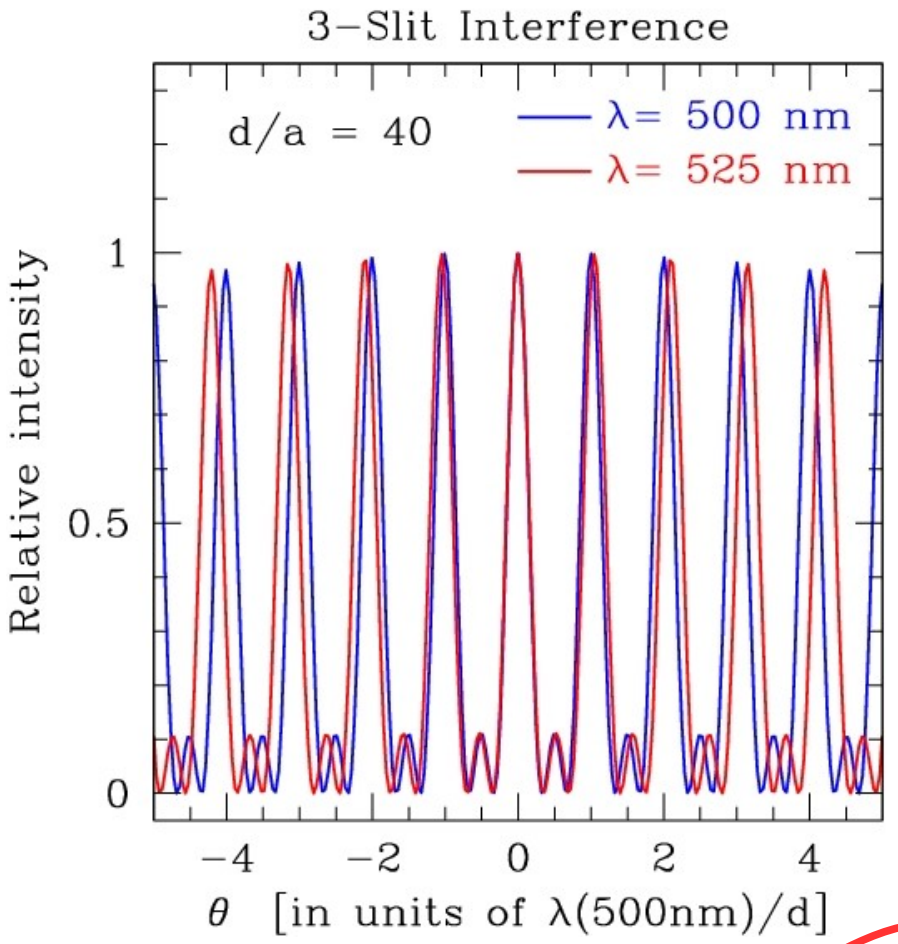
$$\sin\theta_{min} = \frac{x}{f} = \frac{\lambda}{a}$$

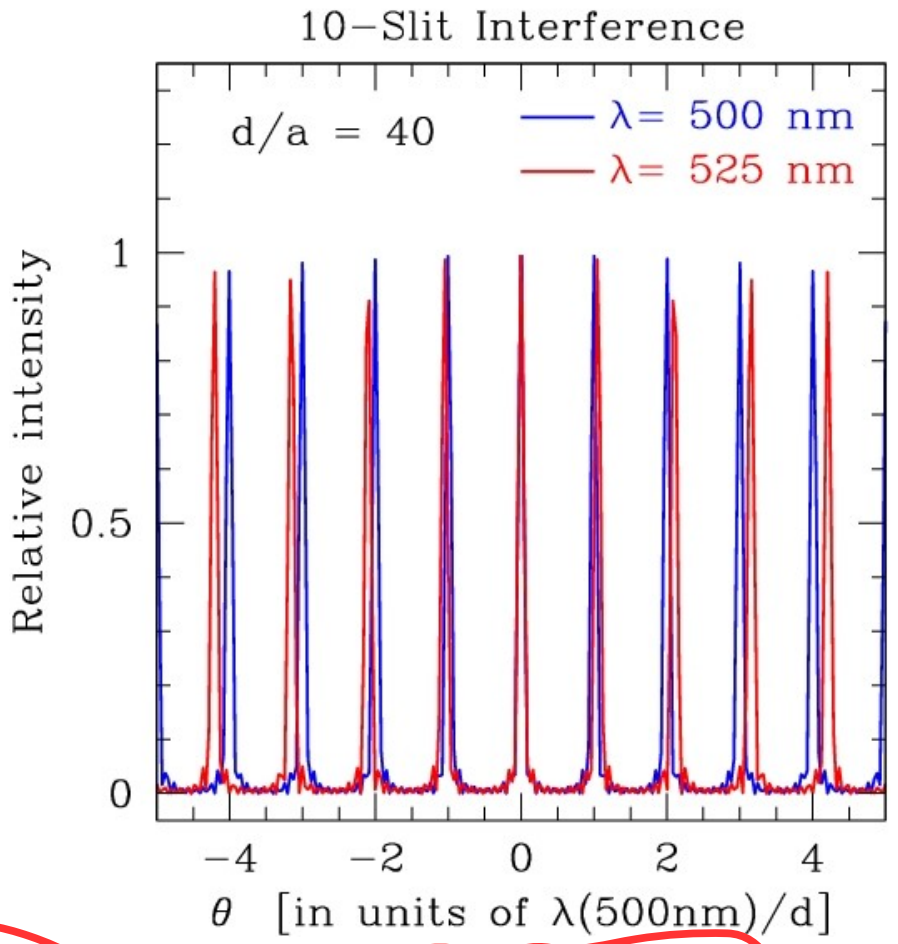




$$\sin\theta_{max} = \frac{x}{f} = \frac{\lambda}{d}$$

Multiple Slit Interference





$$I(\theta) = I(0)\frac{\sin^2(\pi a \sin(\theta)/\lambda)}{(\pi a \sin(\theta)/\lambda)^2} \times \frac{\sin^2(N\pi d \sin(\theta)/\lambda)}{\sin^2(\pi d \sin(\theta)/\lambda)}$$

Single slit diffraction × *N-slit interference*

Multiple Slit Interference

$$I(\theta) = I(0)\frac{\sin^2(\pi a \sin(\theta)/\lambda)}{(\pi a \sin(\theta)/\lambda)^2} \times \frac{\sin^2(N\pi d \sin(\theta)/\lambda)}{\sin^2(\pi d \sin(\theta)/\lambda)}$$

Positions of the principle maxima (m = 0, 1, ...):

$$\theta_{max} = \sin^{-1}\left(\frac{\lambda}{d}m\right)$$

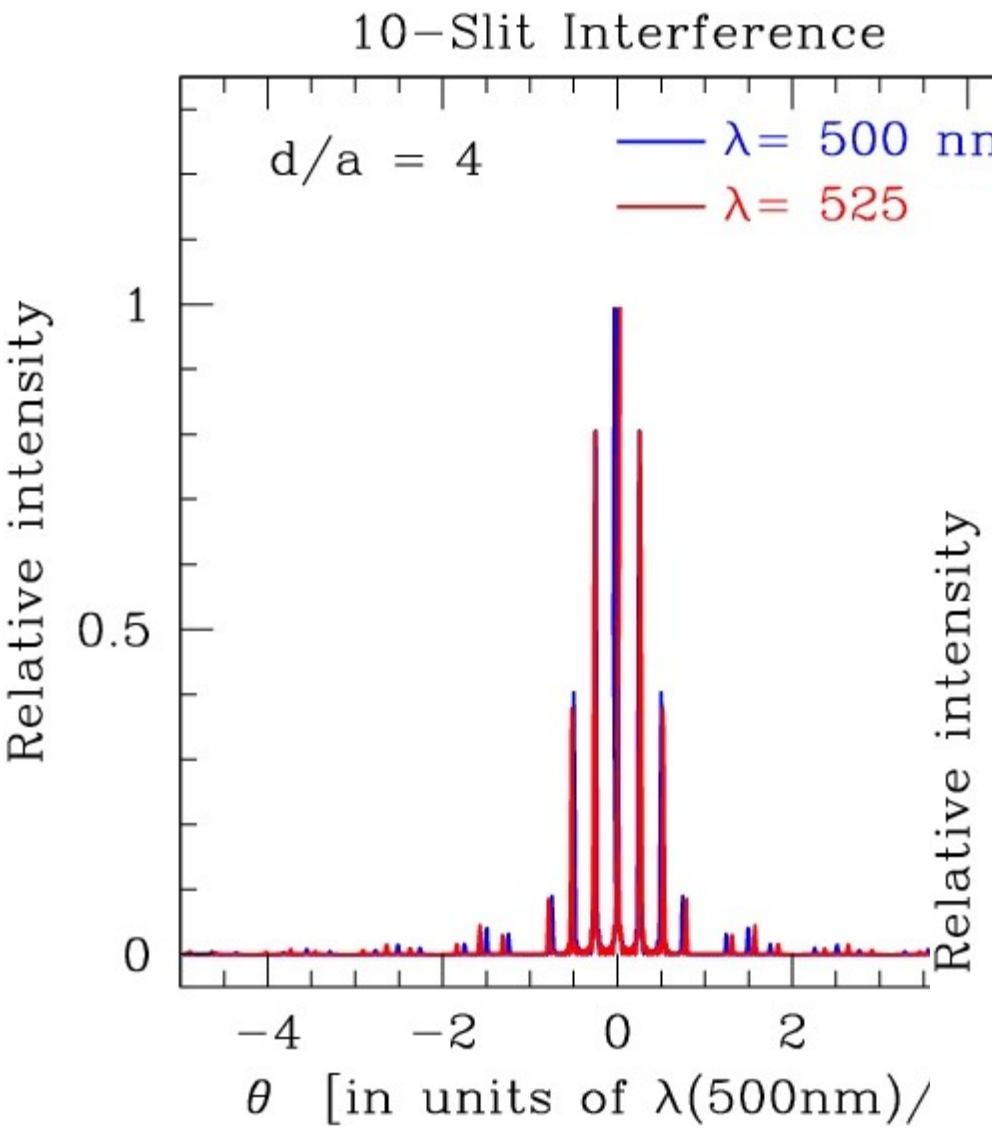
Positions of the minima (n=1, 2, ...):

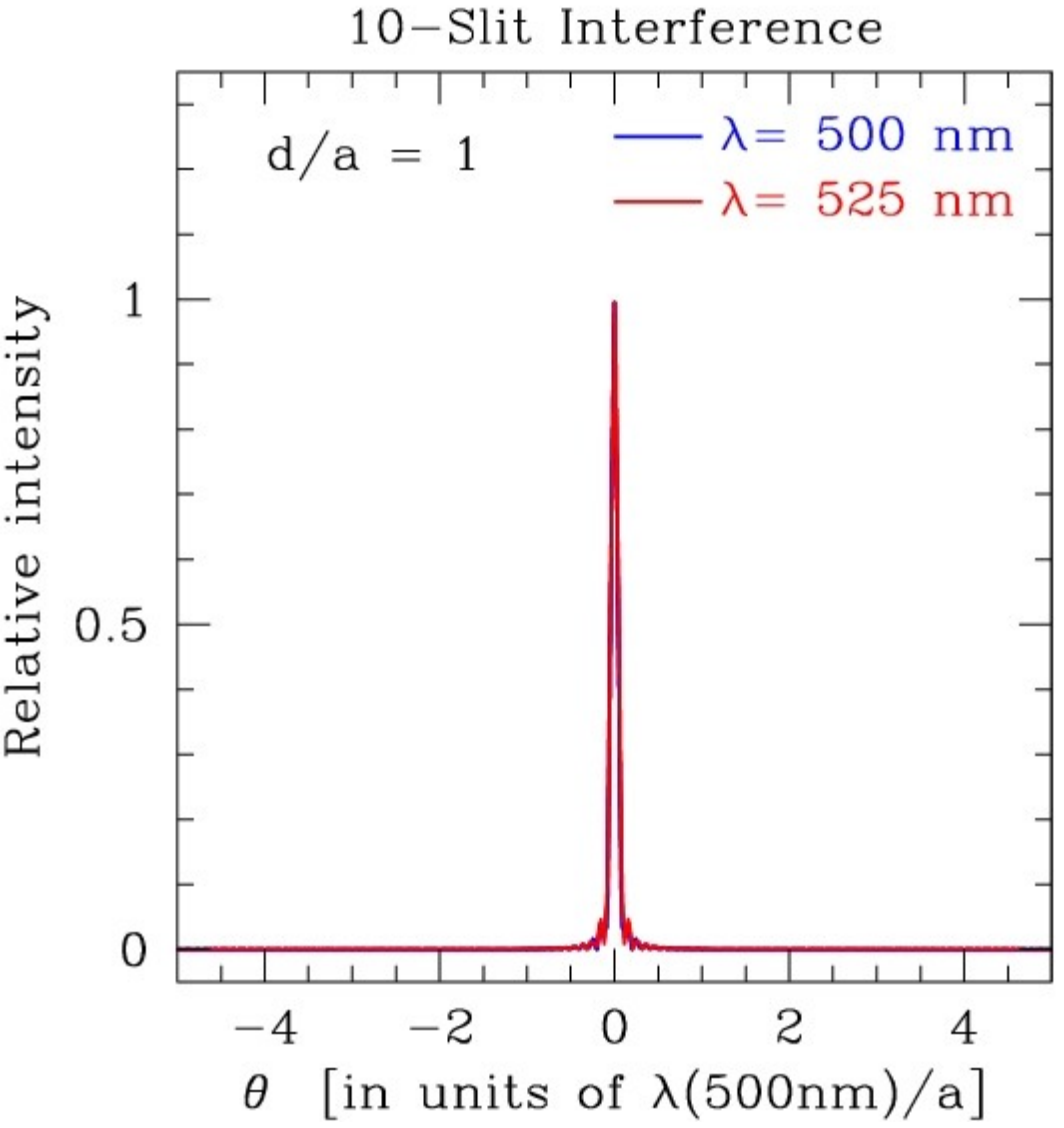
$$\theta_{min} = \sin^{-1}\left(\frac{\lambda}{Nd}n\right)$$

Angular width of the principle maxima:

$$W = \frac{2\lambda}{Nd\cos(\theta)}$$

Selecting Spectrum Order





Blazed Gratings