Spectroscopy Meeting

ATT 2009 Essen

High Resolution Spectroscopy

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Spectroscopic Terms

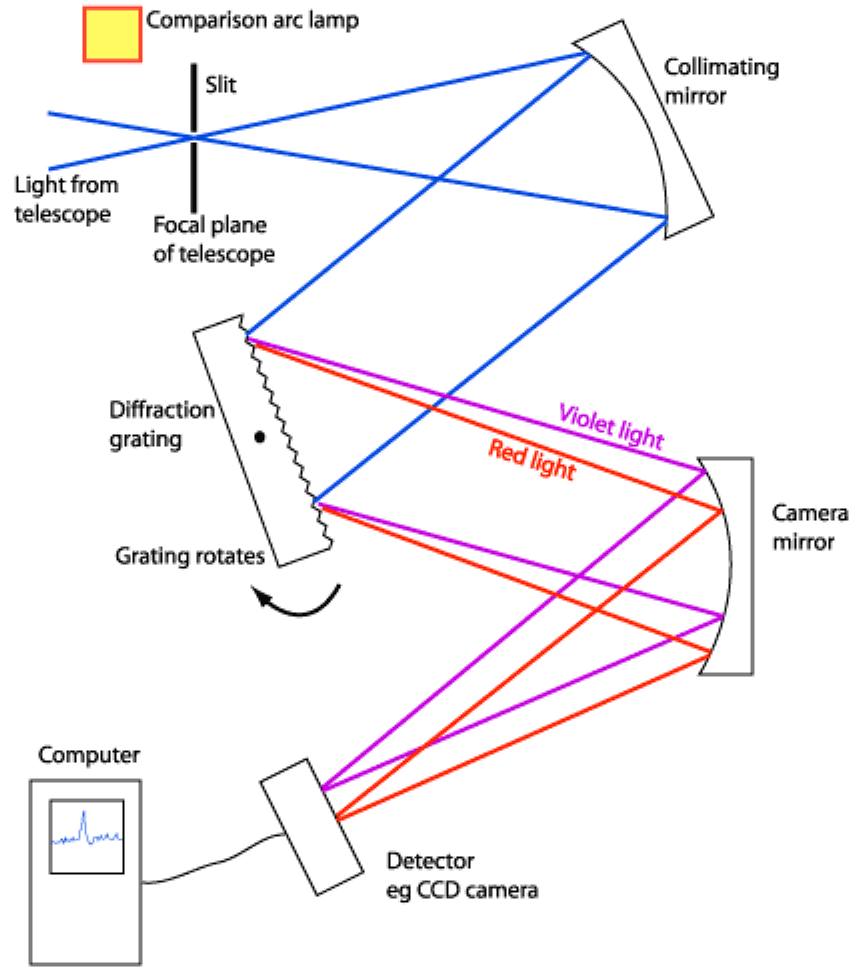
- Spectral resolution, Resolving Power:
  $R = \lambda/\Delta\lambda$, in physical terms $R = c/\Delta v$
  - λ is the wavelength of interest
  - $\Delta\lambda$ is the smallest wavelength interval that can be resolved
  - c the speed of light
  - Δv the doppler shift of the object
- Dispersion – $\Delta\lambda$/pixel or $\Delta\lambda$/Å (informal)

Resolution $\lambda/\Delta\lambda$ Ranges

$10 < R < 1000$	→	low
$1000 < R < 10000$	→	medium
$10000 < R < 100000$	→	high
$100000 < R < \ldots$	→	ultra high

Slit Spectrographs

- **Entrance Aperture**: A slit, usually smaller than that of the seeing disk
- **Collimator**: converts a diverging beam to a parallel beam
- **Dispersing Element**: sends light of different colors into different directions
- **Camera**: converts a parallel beam into a converging beam
- **Detector**: CCD, IR array, photographic plate, etc.



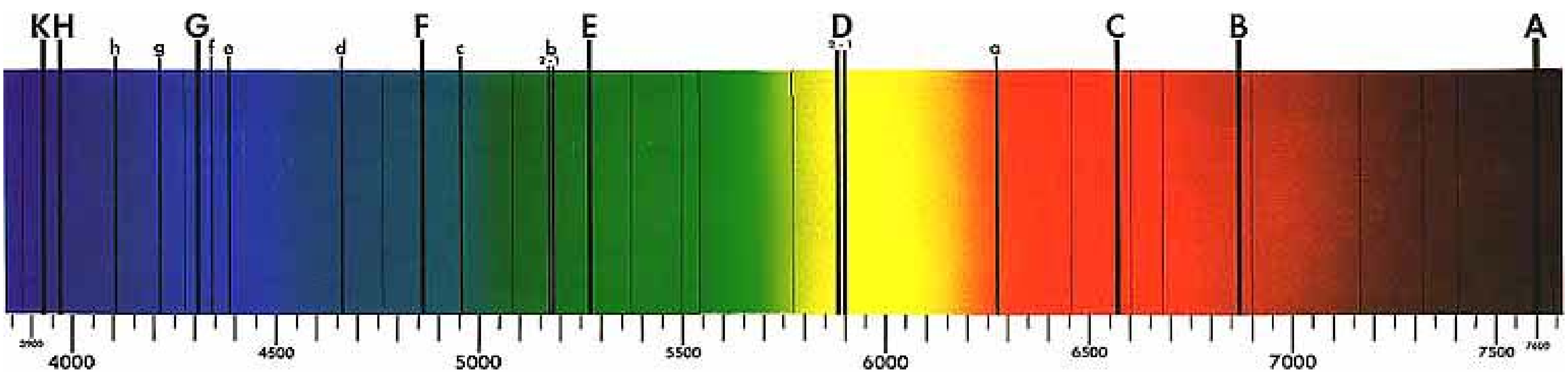
A Schematic Diagram of a Slit Spectrograph

Image from CSIRO

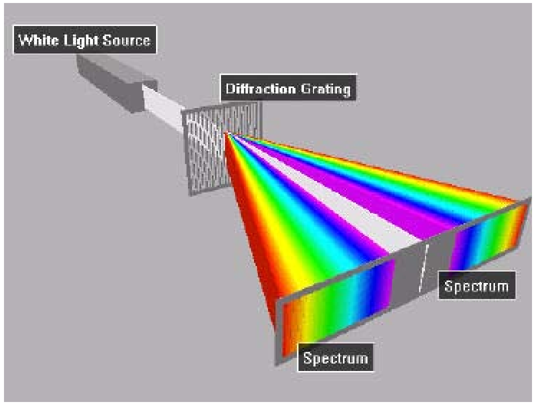
Long Slit Spectroscopy

The higher the resolution

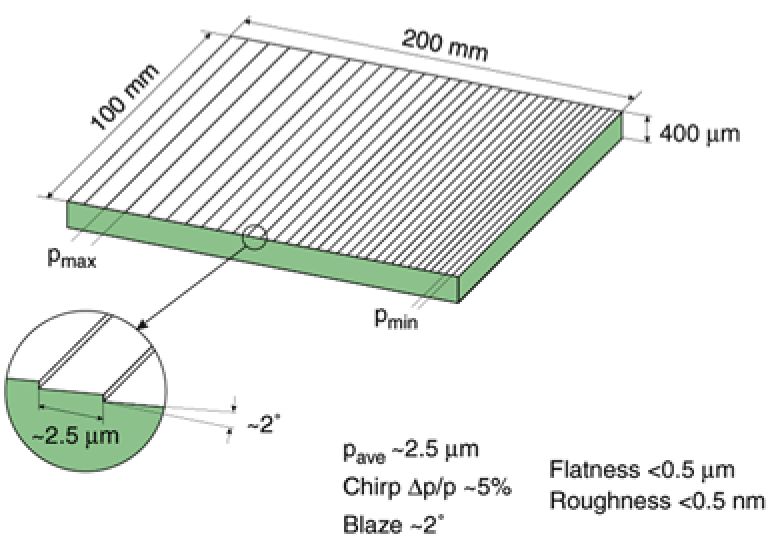
→ the smaller the wavelength band covered.



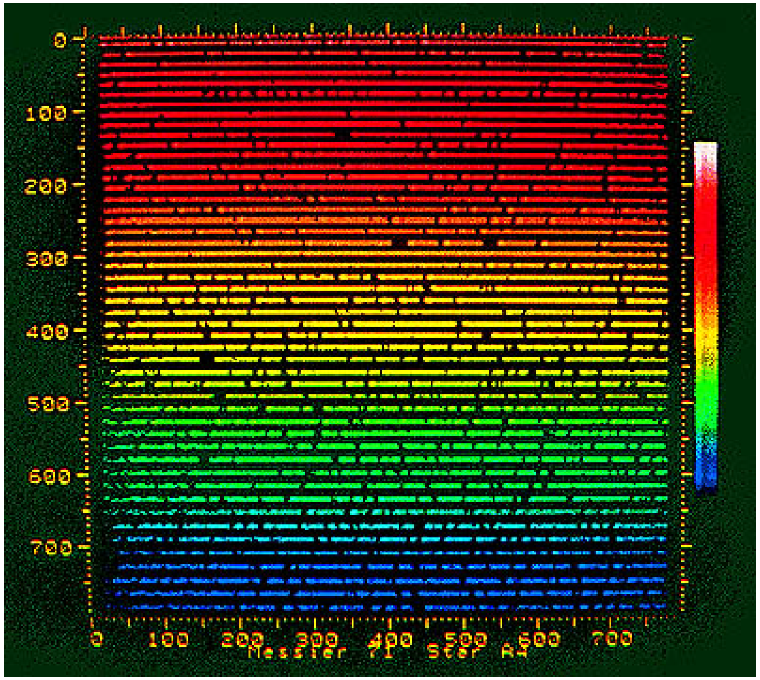
Diffraction Gratings



- Multi-slit diffraction
- reflection gratings and transmission gratings
- most astronomical gratings are reflection gratings



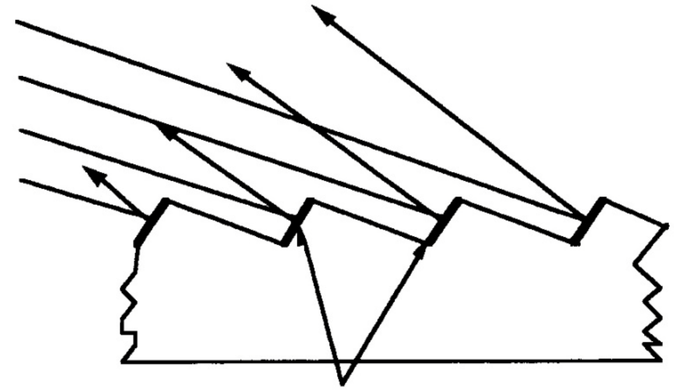
Limitations for High Dispersion

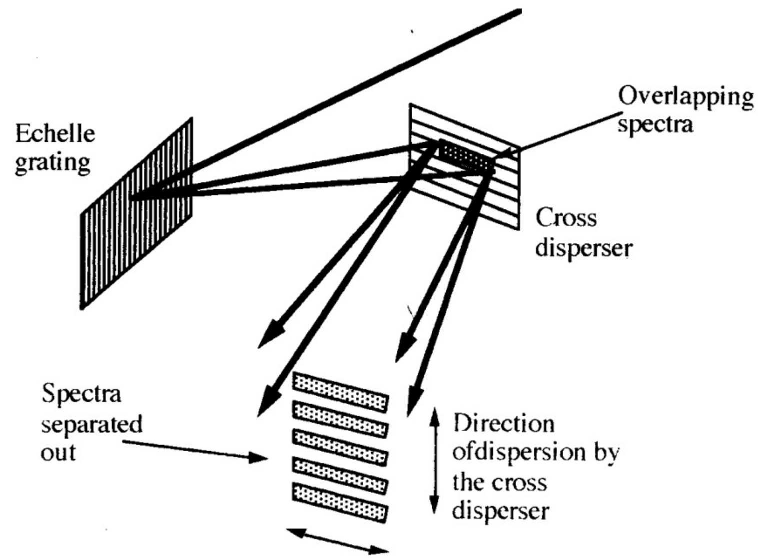


- **Problem**: detector size, shape
  - generally square or 1x2 format
  - a conventional grating spectrograph produces a very LONG high dispersion spectrum that won't fit on a CCD
- **Solution**: the echelle grating
  - works in high orders (n=100)
  - a second dispersing element spreads the light in a perpendicular direction

Echelle Gratings

- To increase spectral resolution, increase the order at which a grating is used
- For high orders, must increase a and b in the grating equation (to ~50-75°)
- The spectral range for each order is small so the orders overlap
- Separate the orders with a second disperser (cross disperser) acting in a perpendicular direction.





C. R. Kitchin, *Optical Astronomical Spectroscopy*

Summary High vs. Low Resolution Spectroscopy

High resolution spectroscopy requires:

Gratings with larger number of lines per mm

→ Larger dispersion

→ Larger Detector

→ More complex Optics