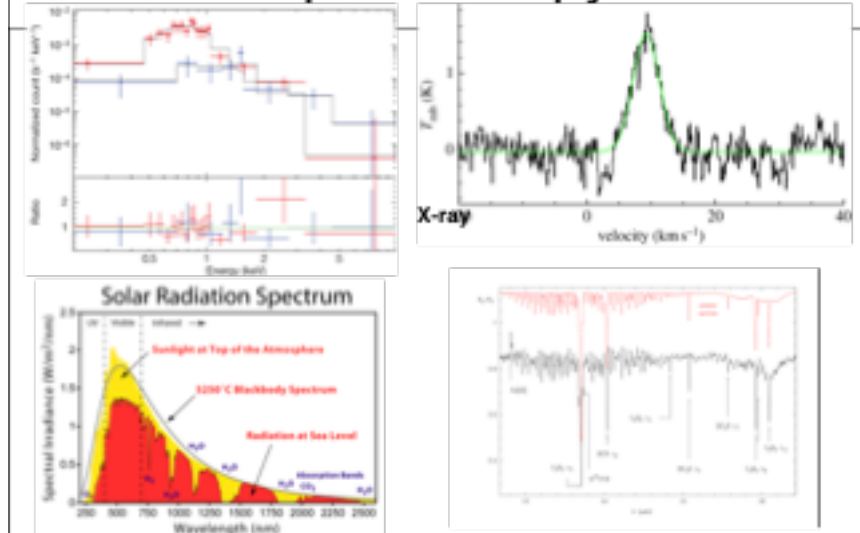


# Spectroscopy

- Physical origin of spectral lines
  - Atomic transitions ("recombination").
  - Neutral line emission ("spin-flip").
  - Spinning molecules.
- Uses of spectral lines
  - Redshift.
  - Stellar/gas dynamics.
  - Measuring cloud densities.
- How to spread out light (UV/Optical/IR)

1

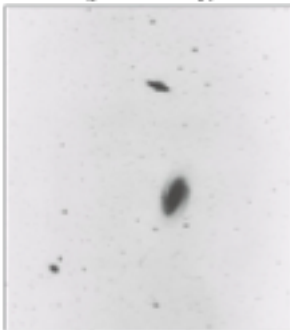
# Spectroscopy



2

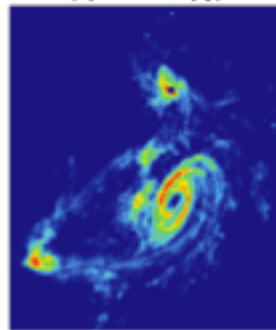
# Sky-Resolved Spectroscopy: M81

Optical continuum (photometry)



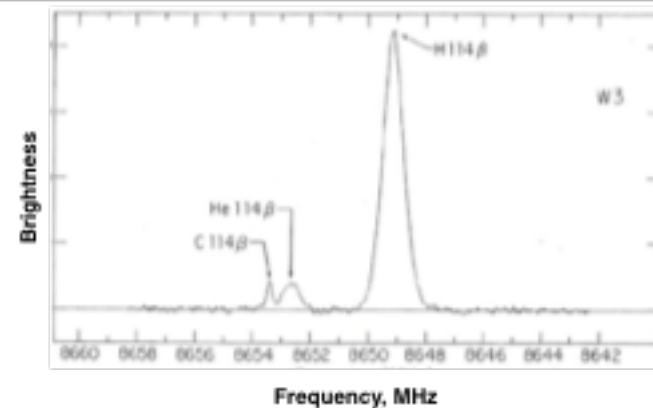
Optical photometry:  
Detecting continuum blackbody light from stars

Radio 21cm Hydrogen Line (spectroscopy)



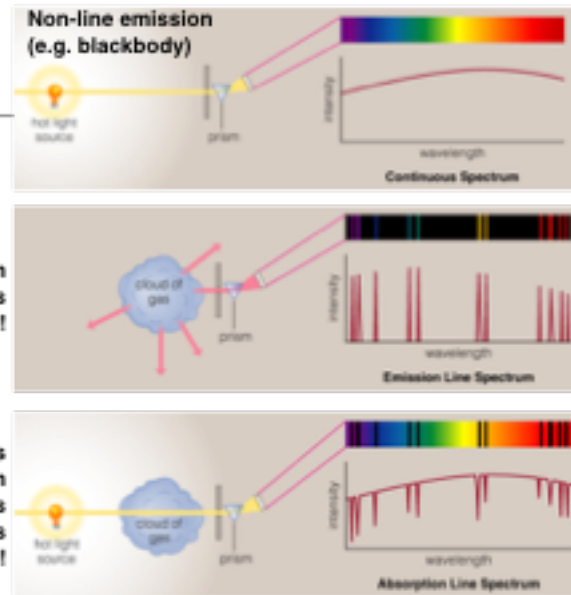
Radio spectroscopy:  
Imaging only Neutral Hydrogen emission line.

3



4

## Kirchoff's Laws: a Reminder



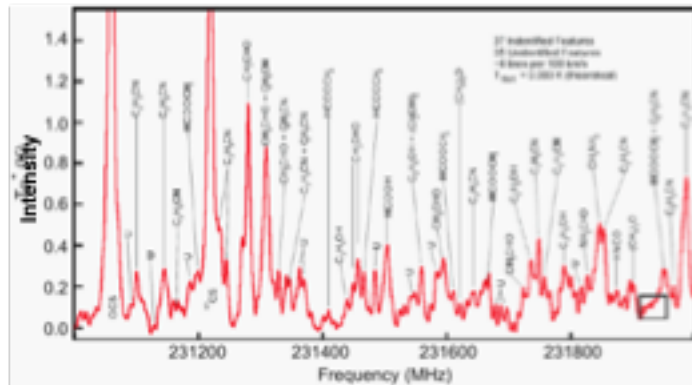
5

## Cool applications of lines

- Line frequency: Identifying resident atoms/ molecules.
- Line frequency: Radial velocities.
- Line width: Bulk gas dynamics, temperatures.
- Intensity: Measuring total gas masses.

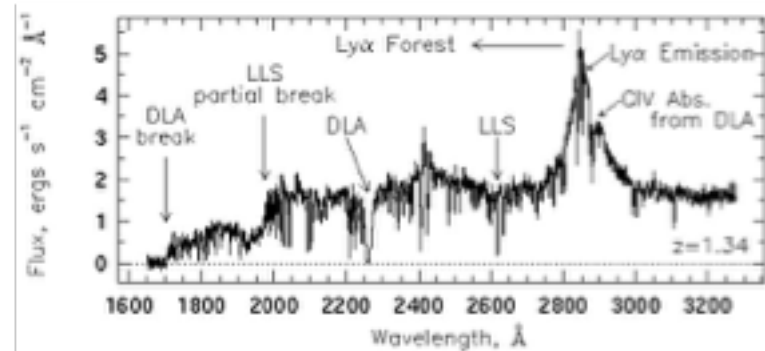
6

## Spectrum of Milky Way Center



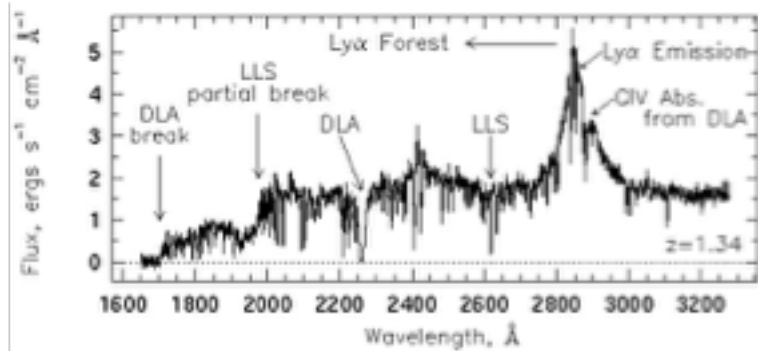
7

## Lyman alpha from distant galaxy



8

## Lyman alpha from distant galaxy



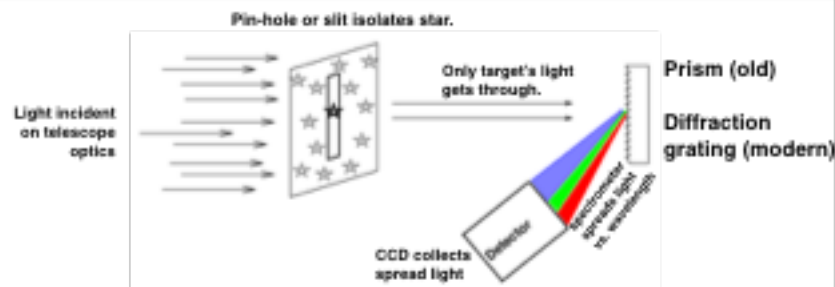
9

## Cool applications of lines

- Line frequency: Radial velocities.
- Line frequency: Identifying resident molecules.
- Line width: Bulk gas dynamics, temperatures.
- Intensity: Measuring total gas masses.

10

## UV/Optical/IR Spectroscopy



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