Spectral Classification of B-type Stars

Chapter 4
Gray & Corbally

Katie Lester

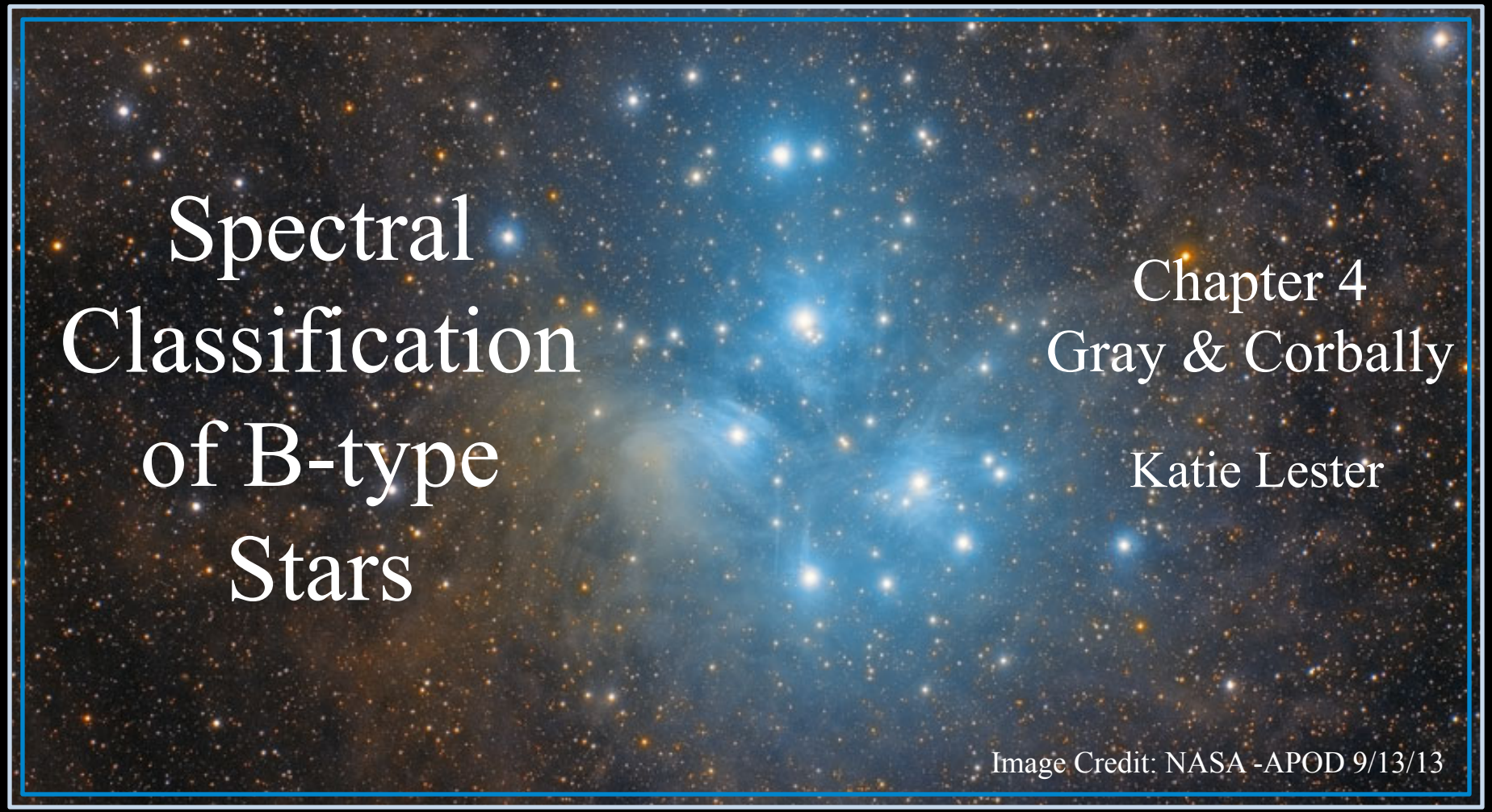


Image Credit: NASA -APOD 9/13/13

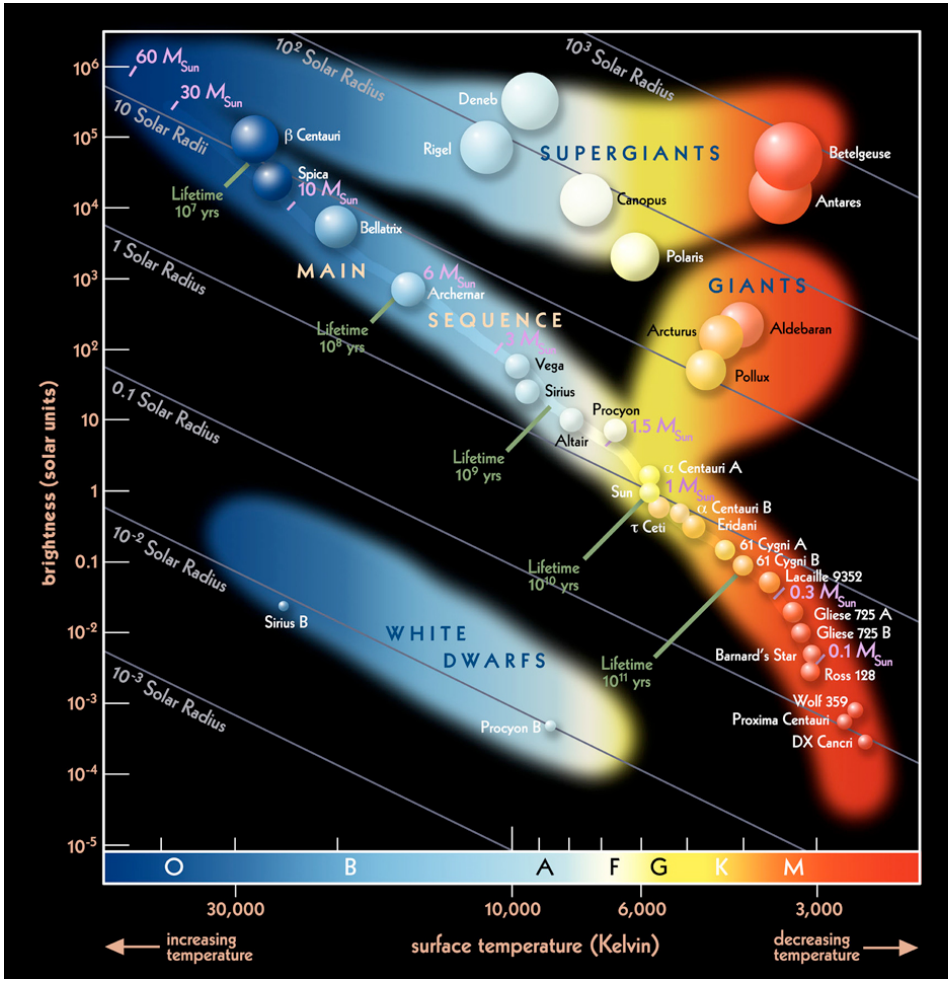
Properties

Temperature: 10,000 – 30,000 K

Mass: 2 – 20 M_{sun}

Luminosity: 60 – 30,000 L_{sun}

Abundance: 0.1% of all stars



(Carroll & Ostlie)

Image Credit: ESO

Formation and Evolution

- Form in molecular clouds in spiral arms of the galaxy
- Usually found in binary systems with other massive stars
- Main sequence lifetime: 10-100 million years
- Evolves to become a supergiant
- Dies in a SN explosion to become white dwarf or neutron star

Image Credit: ESA/NASA

Famous B stars

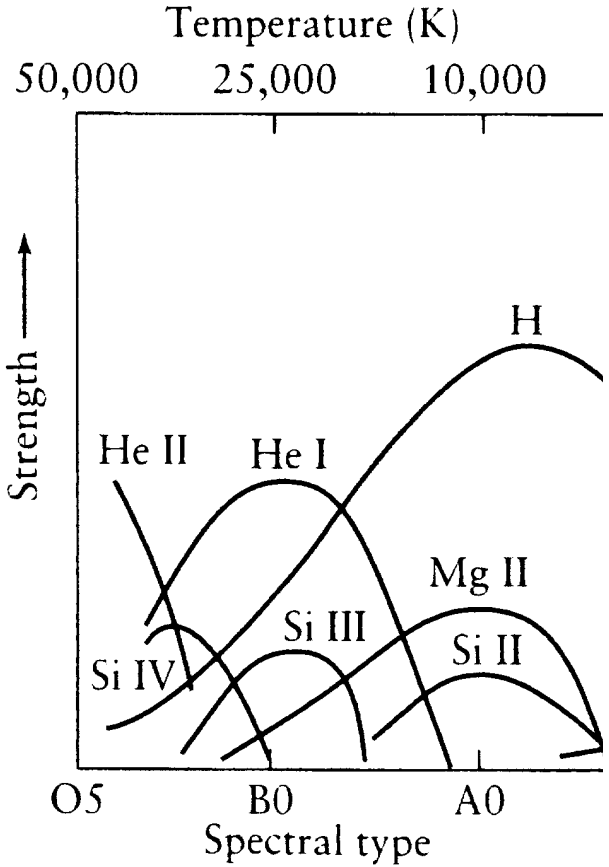
- Rigel (Orion)
  - B8 Ia
- Regulus (Leo)
  - B7 V
- Pleiades Cluster (M45)
  - Seven brightest are B or Be type stars

Many of the brightest naked eye stars in the sky are B stars!

Image Credit: Carroll & Ostlie

General spectral characteristics

- Energy distribution peaks in the UV and blue
  - Ex) B5 peaks around 1800Å
- Spectra dominated by H I and He I lines
- Some lines from ionized metals
  - Ex) O II, Si II, Mg II



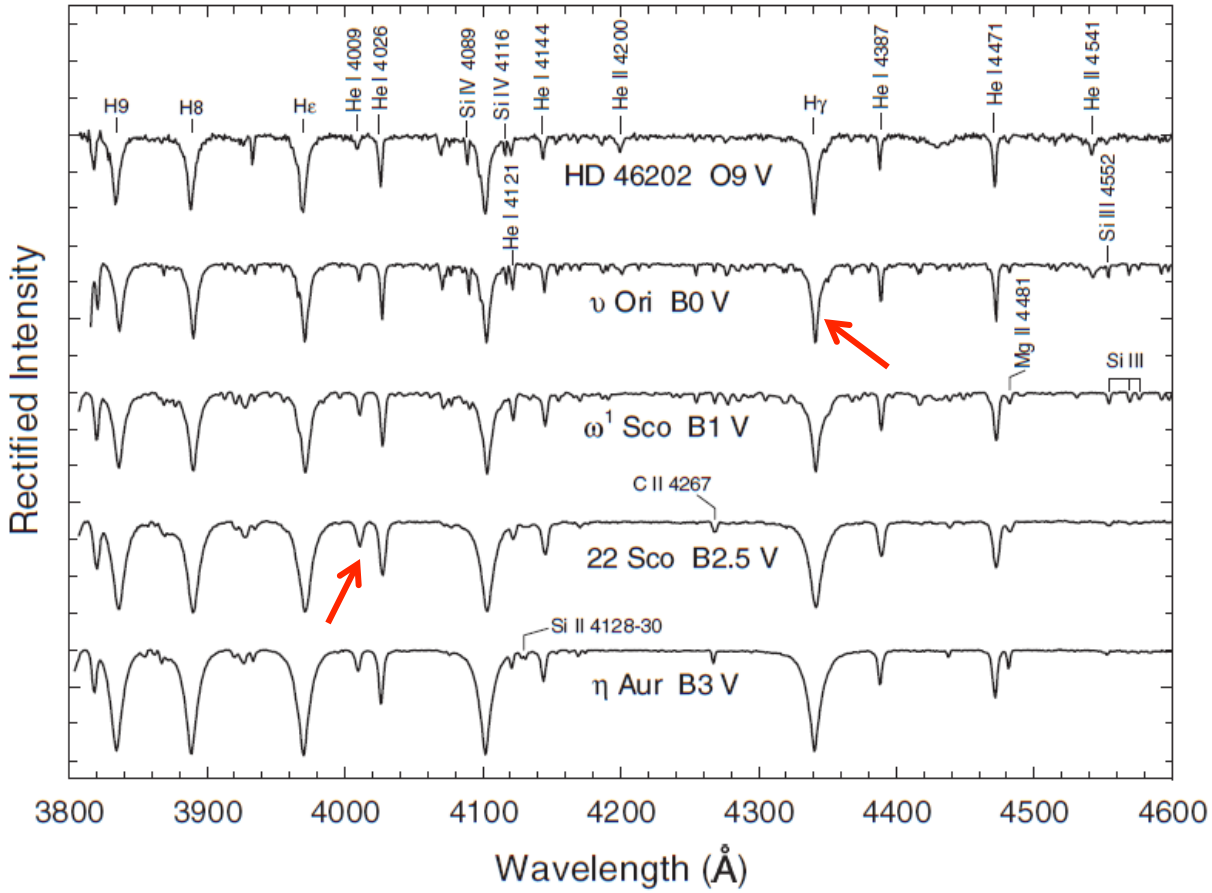
(Gray & Corbally)

Early B stars (B0-B3)

Decreasing ↓ Temperature:

Optical
- Balmer line strength ↑
- He I lines peak at B2

UV
- Si III / Si IV ratio
- C II / C III ratio
- P Cygni resonance lines

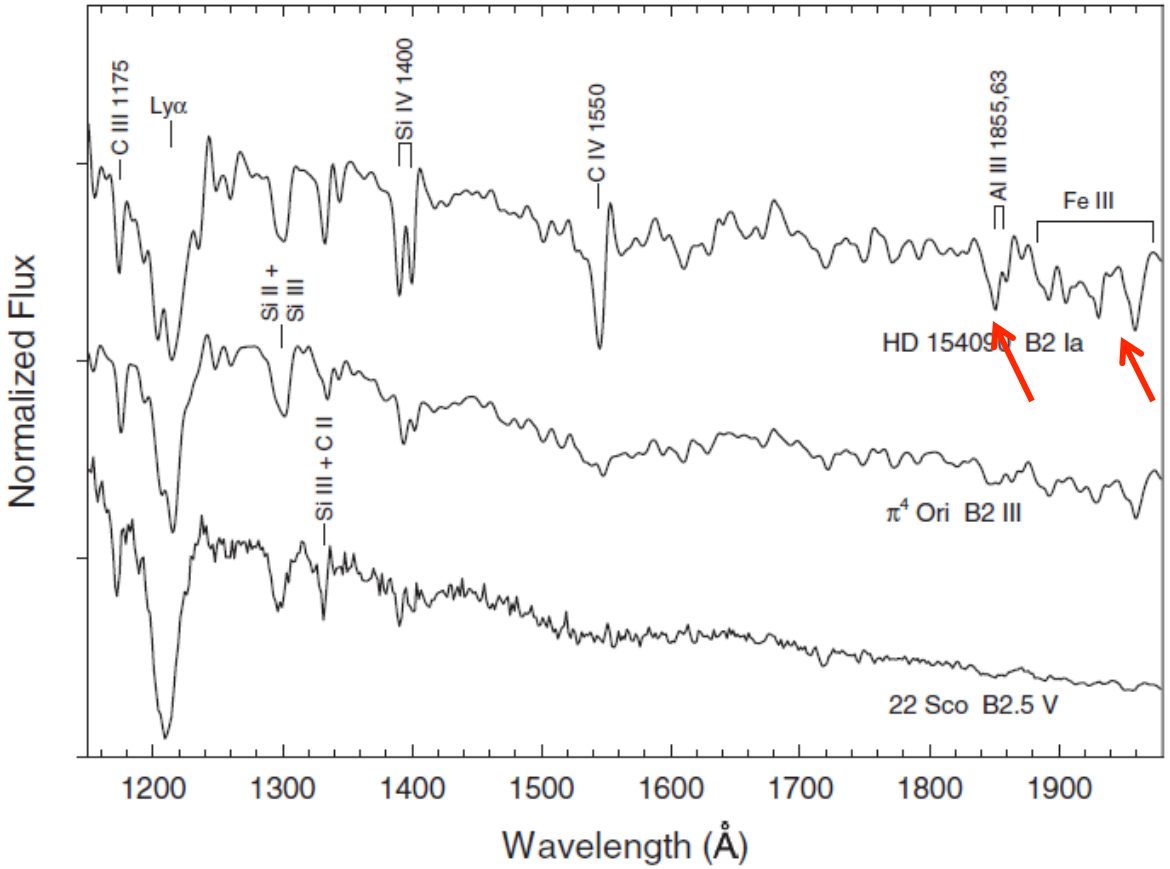


Early B stars (B0-B3)

Increasing ↑ Luminosity:

Optical
- He I strength ↓
- Balmer line width ↓
- Si II and O II strength ↑

UV
- Al III strength ↑
- Fe III strength ↑

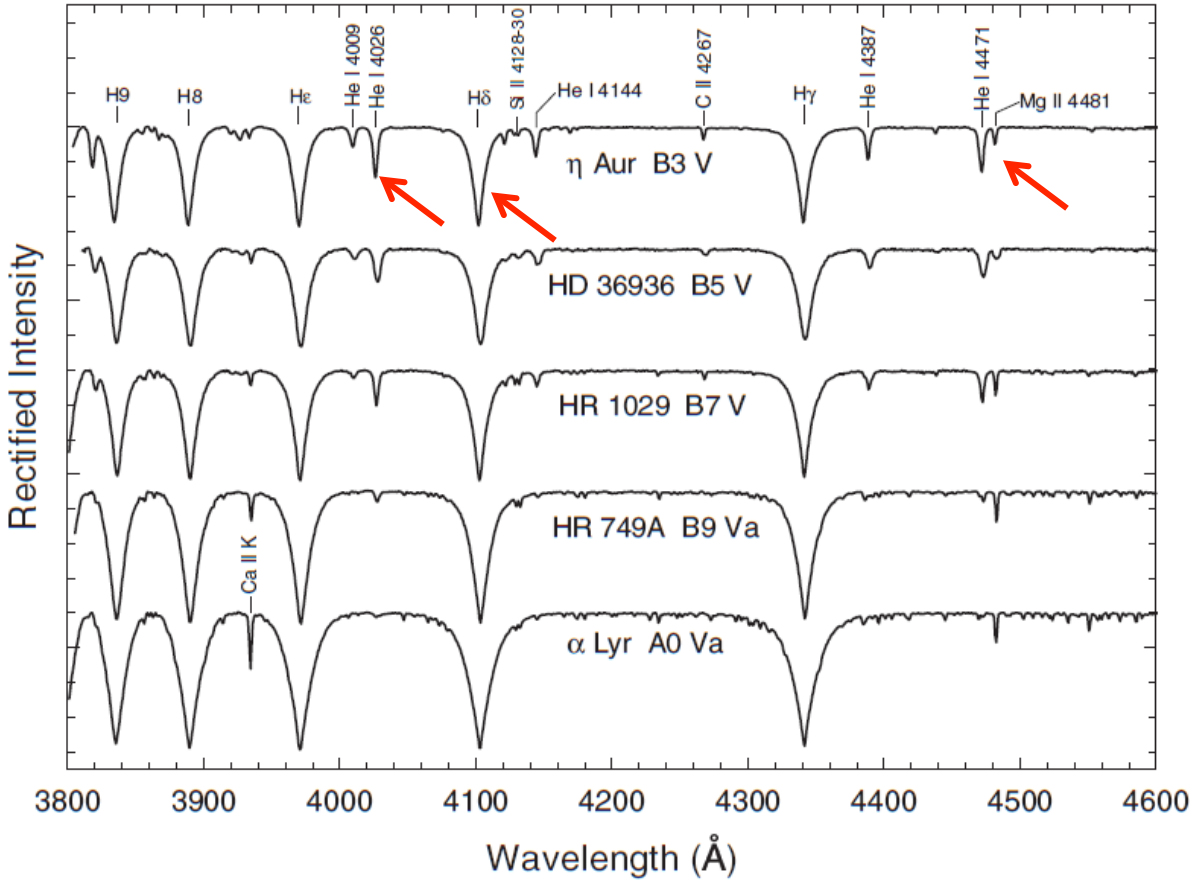


Late B stars (B3-B9)

Decreasing ↓ Temperature:

Optical
- Balmer line strength ↑
- He I strength ↓
- Mg II strength ↑

UV
- Si II / Si III ratio
- C II / C III ratio

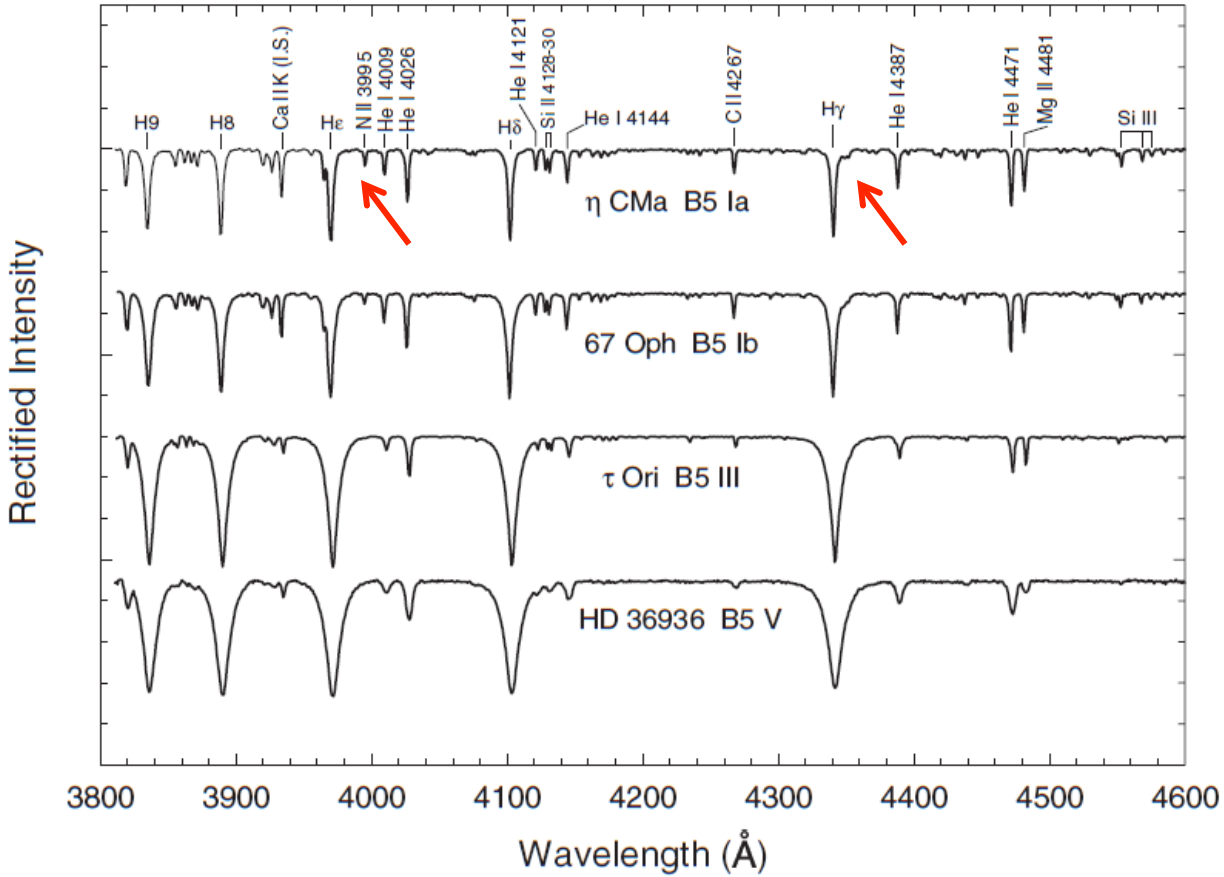


Late B stars (B3-B9)

Increasing ↑ Luminosity:

Optical
- Balmer line width ↓
- N II line strength ↑

UV
- Fe III strength ↑



Compositional variations

- B stars often have weird chemical abundances
  - Gravitational settling -vs- radiative elevation
  - Varies based on surface gravity and UV output

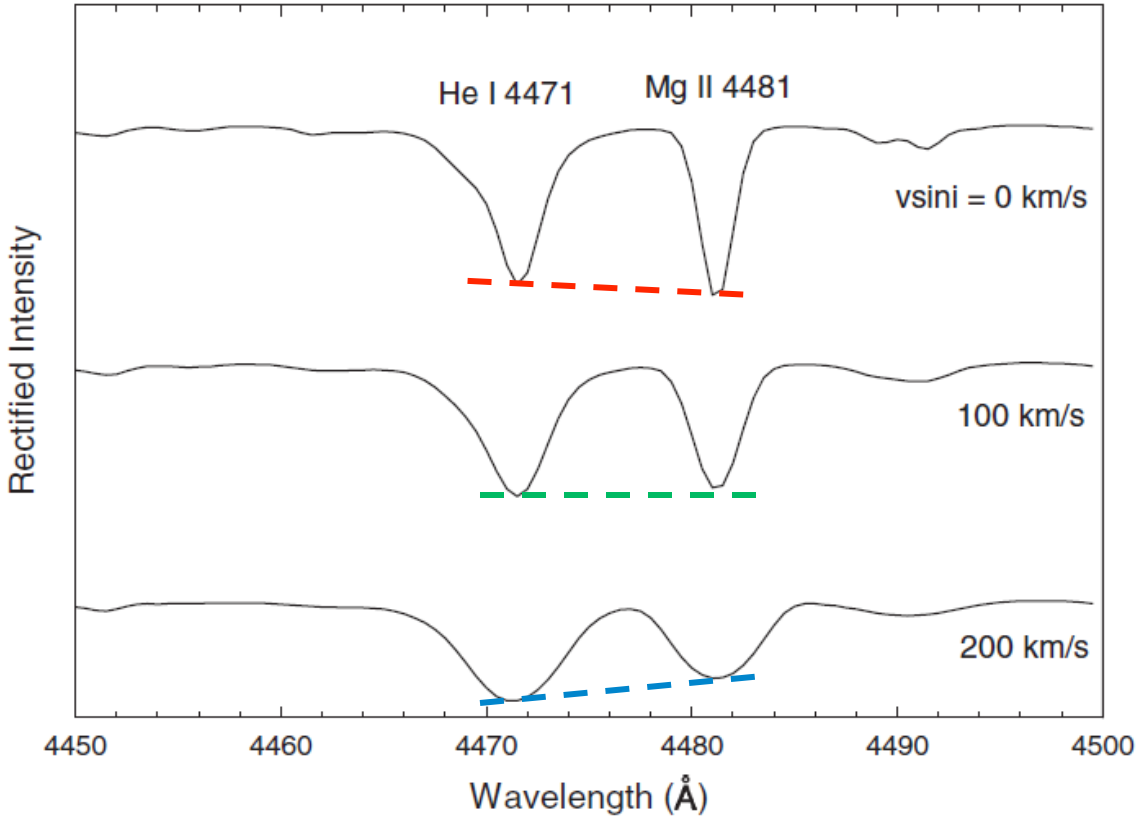
- Early B stars – often Helium strong
  Late B stars – often Helium weak
  - Use Si IV or Si III line strengths to determine temperature
  - Use Fe III, Al III, or N II line strengths to determine luminosity

Rotational broadening

- Edges of the star are Doppler shifted
- Affects the shape of the absorption lines

Solutions:

- Use the equivalent width instead of the line depth
- Compare to a set of standard stars that rotate



Other types of B-type stars

- Classical Be stars
- B[e] stars
- Herbig Ae/Be stars
- Algol systems

} Emission line B stars

- B stars out of the galactic plane

Classical Be Stars

Central B star

+

Decretion disk

Image Credit: Bill Pounds

Classical Be Stars

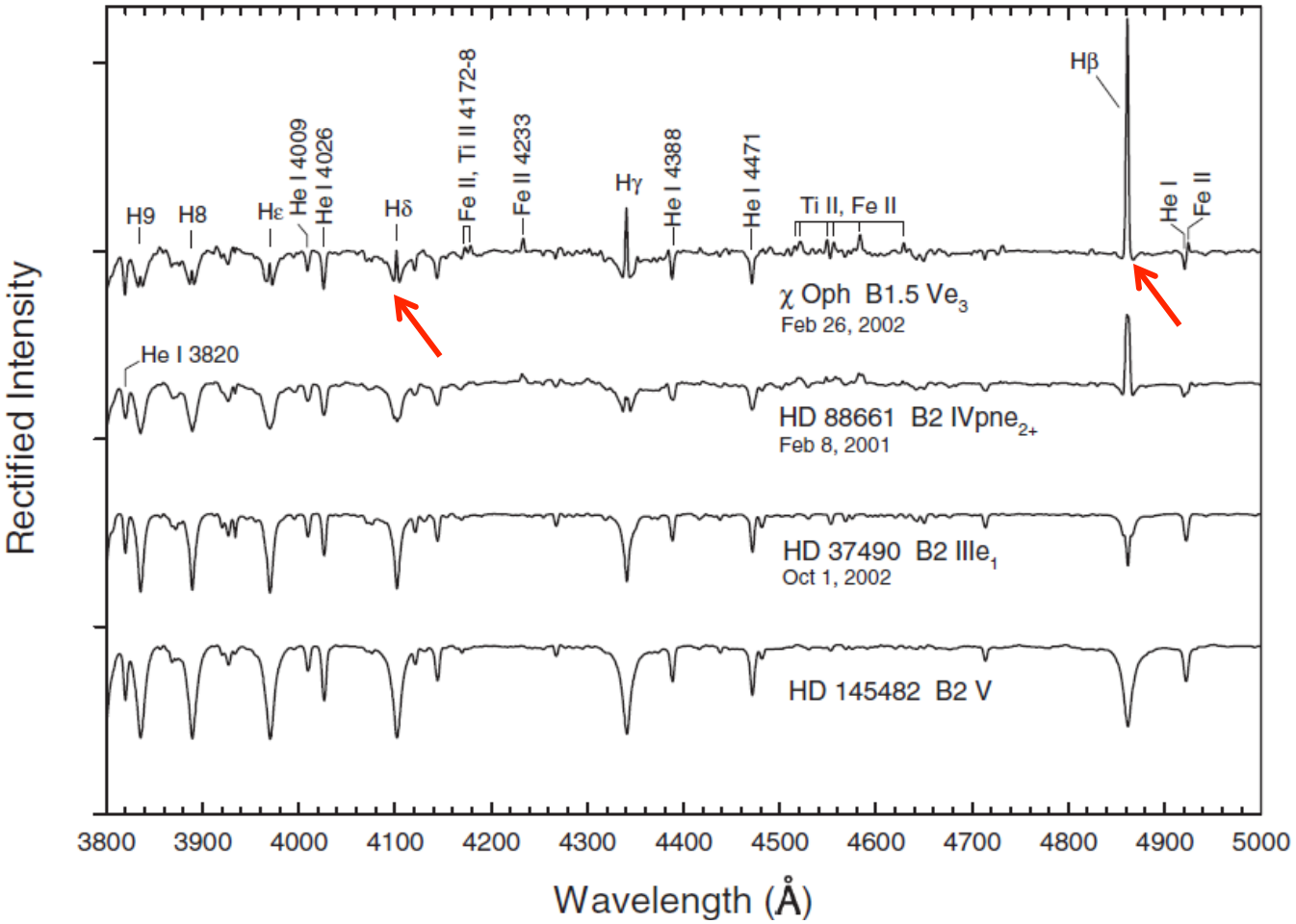
Central B star

- Main sequence dwarfs or giants
- Rapid rotator (vsini > 200 km/s)
- UV photons ionize the disk

Decretion disk (gas)

- Star is losing mass onto disk
- Rotating differentially
- Radiated in the optical and IR (free-free emission)

Image Credit: Bill Pounds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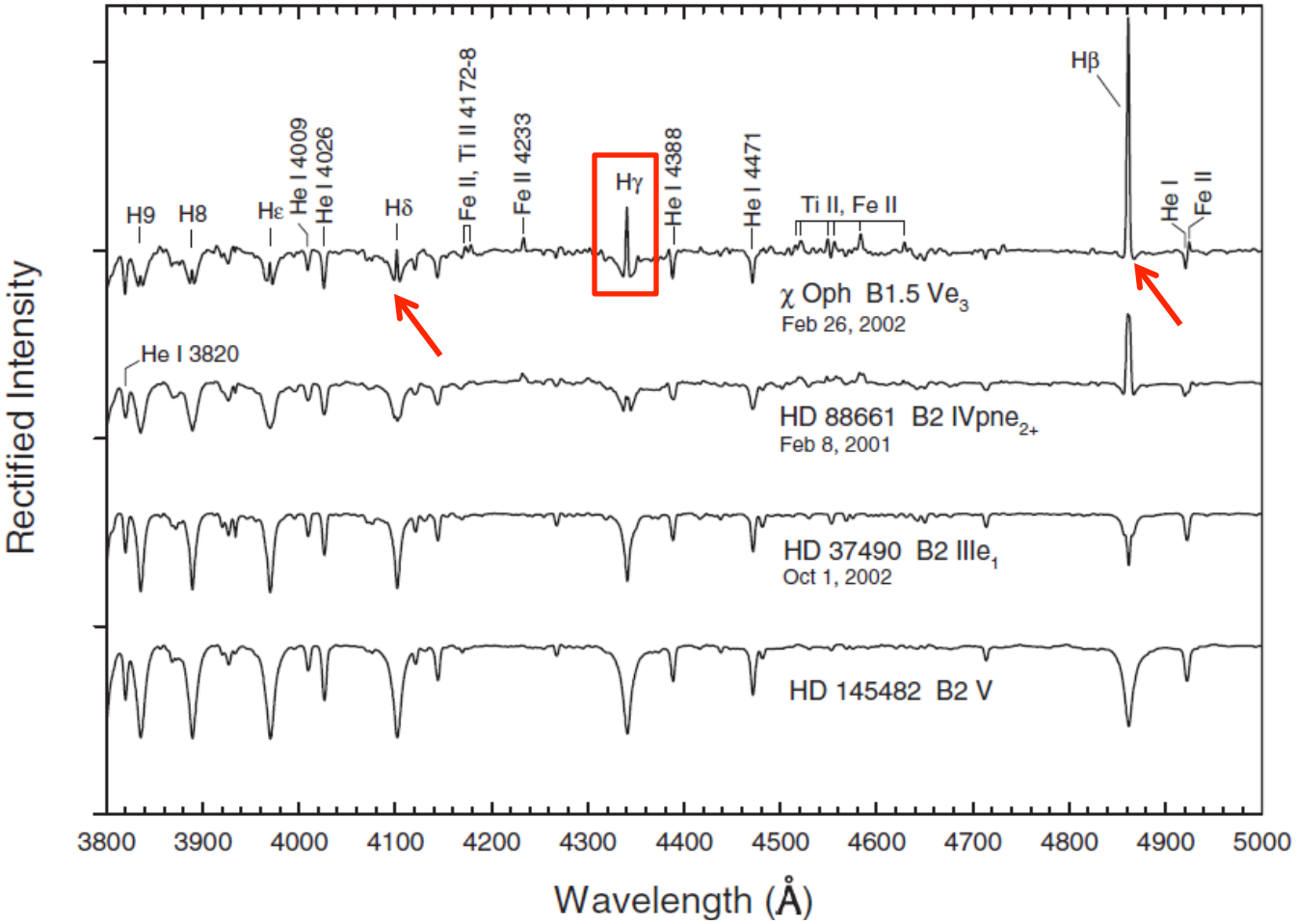
H9
H8
Hε
He I 4009
He I 4026
Hδ
Fe II, Ti II 4172-8
Fe II 4233
Hγ
He I 4388
He I 4471
Ti II, Fe II
Hβ
He I
Fe II
χ Oph B1.5 Ve3
Feb 26, 2002
He I 3820
HD 88661 B2 IVpne2+
Feb 8, 2001
HD 37490 B2 IIIe1
Oct 1, 2002
HD 145482 B2 V
3800
3900
4000
4100
4200
4300
4400
4500
4600
4700
4800
4900
5000
Wavelength (Å)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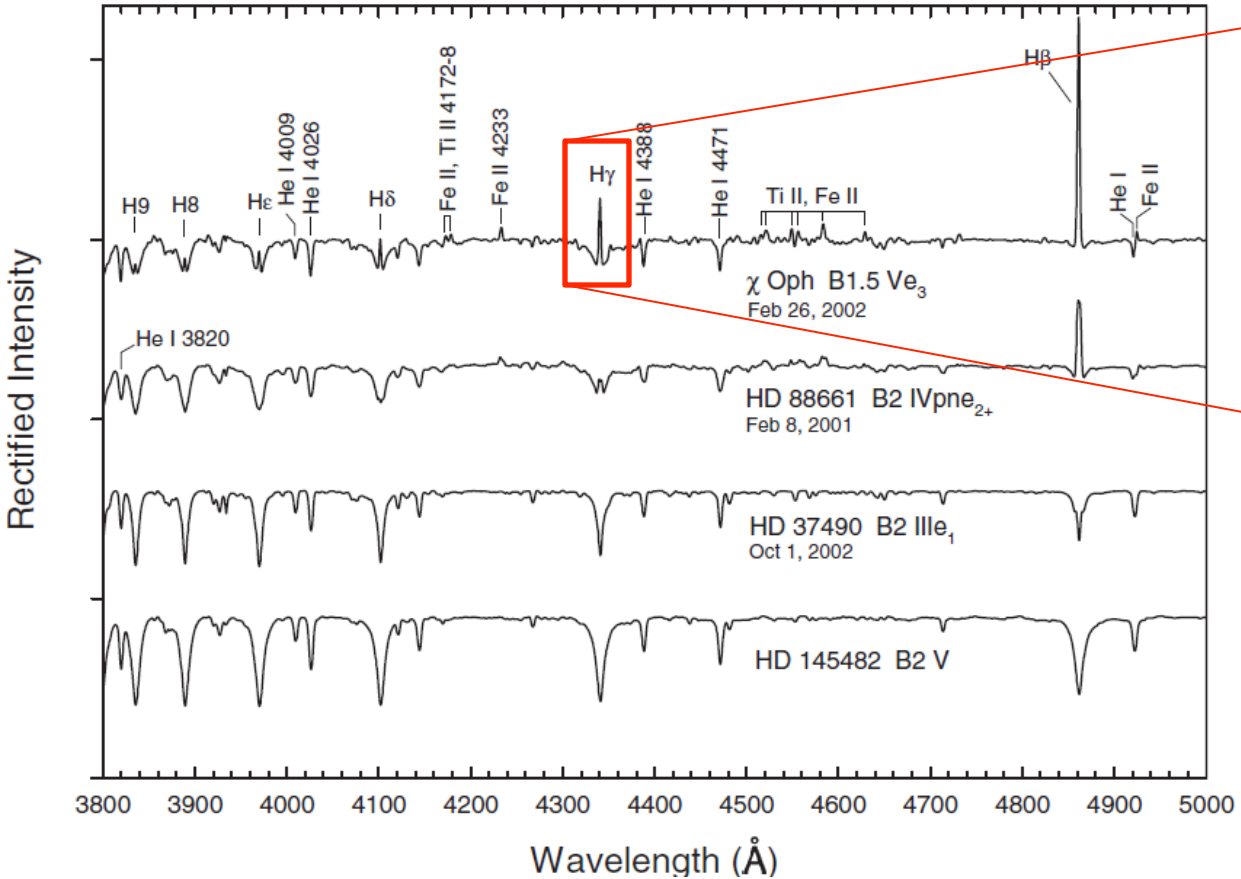
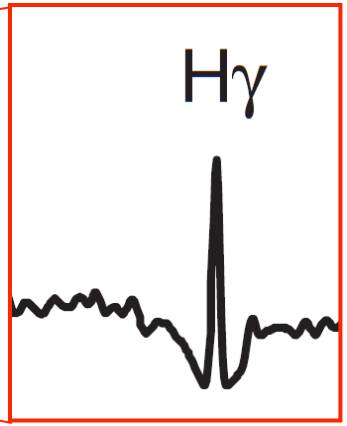




Central star – wings of photospheric Balmer lines

Disk – shape of emission peaks...

Be star spectra

- Infrared excess from disk emission
- Emission features can vary on timescales from minutes to years
- Absorption features should be constant

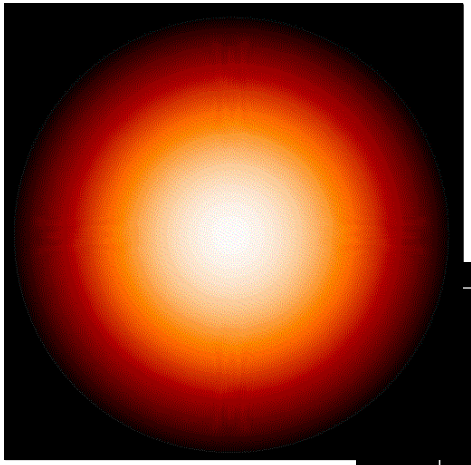
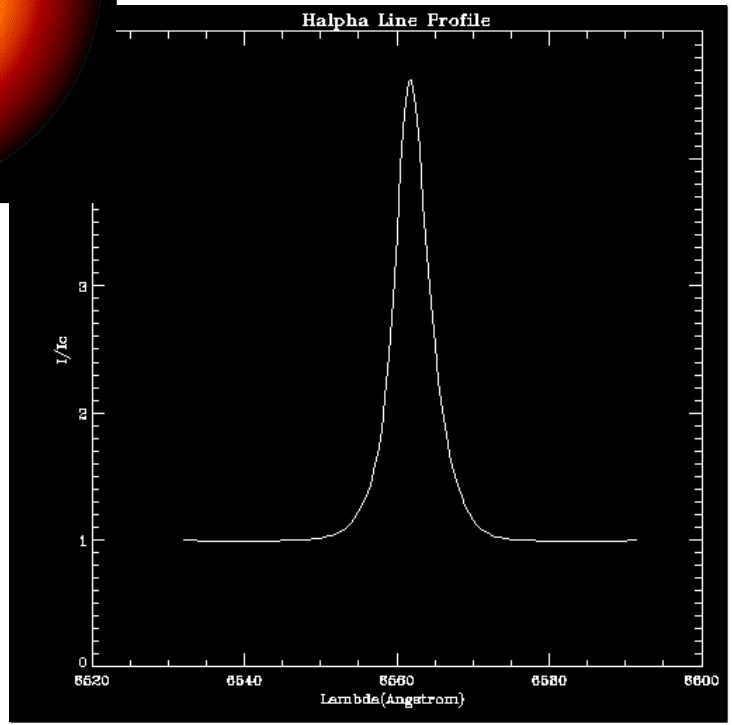
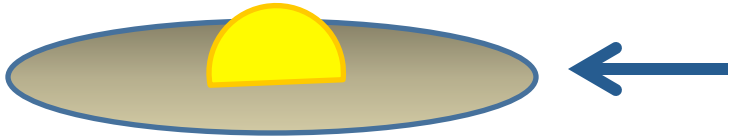


Image Credit: Philippe Stee / Observatoire de la Côte d'Azur

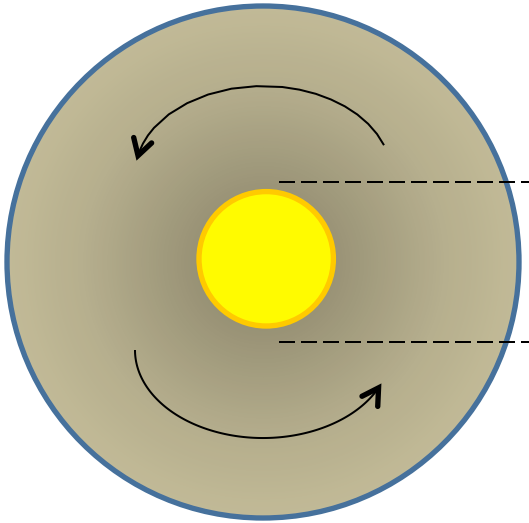


Edge-on line profiles



Inclination ≈ 90°

Red shifted emission



Absorption through optically thick disk

Blue shifted emission

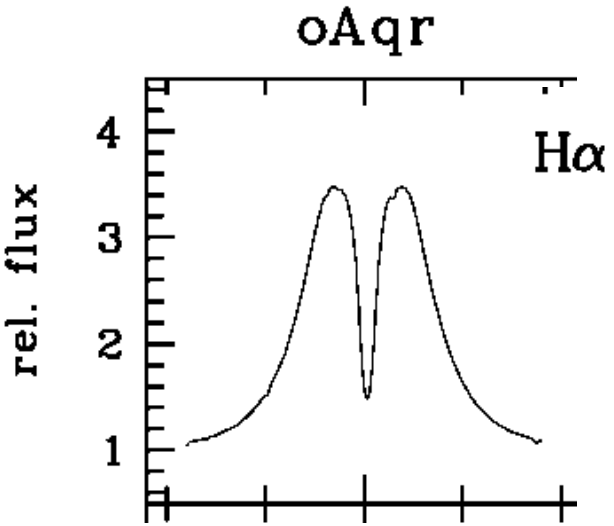
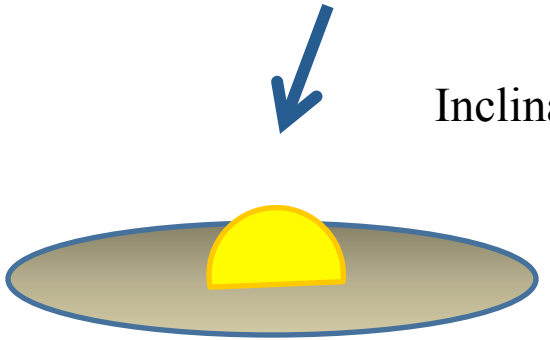


Image Credit: Porter & Rivinius (2003)

Top view line profiles



Inclination ≈ 0°

Emission from the disk overpowers the absorption from the star.

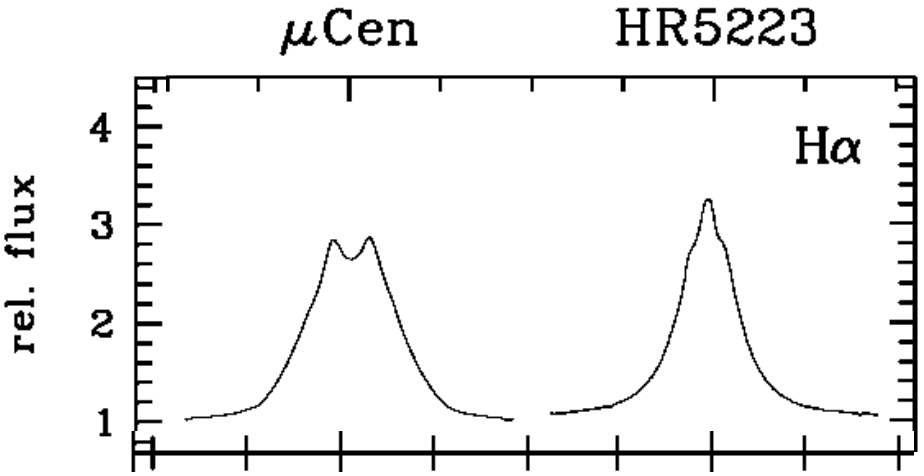


Image Credit: Porter & Rivinius (2003)

Summary

- B stars emit blue and UV light
- Mostly H I and He I absorption lines
- Often rotate very rapidly
- Can have disks that create emission lines

Works Cited

- Gray, R.O. & Corbally, C.J. *Stellar Spectral Classification.* 2009, Princeton University Press.
- Kaler, J.B. *Stars and their Spectra*. 2011, Cambridge University Press.
- Carroll, B.W. & Ostlie, D.A. *Introduction to Modern Astrophysics.* 2007, Pearson.
- Collins, G.W. *Physics of Be Stars.* 1987, Cambridge University Press.
- Porter, J.M. & Rivinius, T. 2003, PASP, 115, 1153
- NASA/ESA/STScI media gallery


Questions ?
Image Credit: NASA -APOD 9/13/13