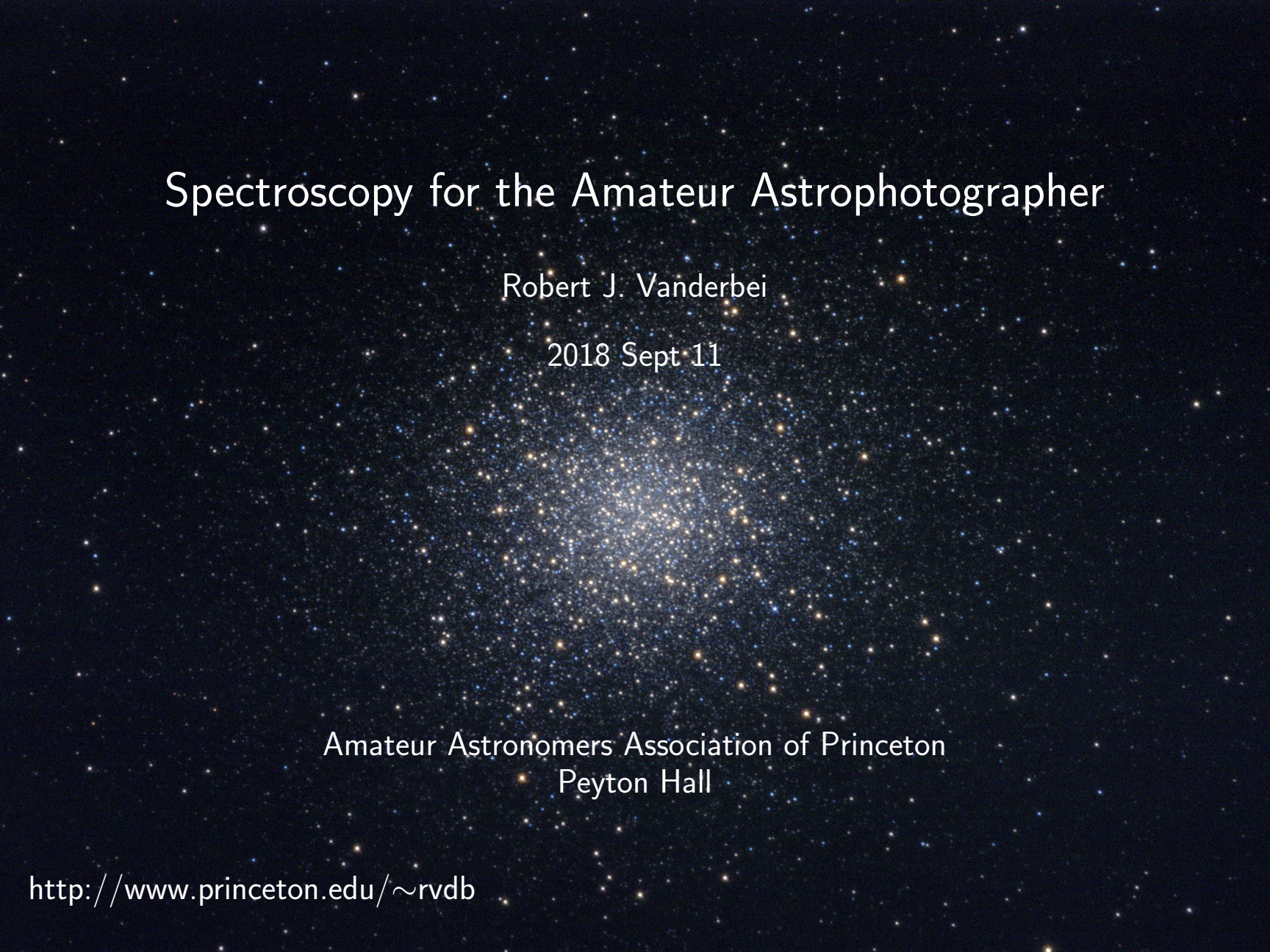


Spectroscopy for the Amateur Astrophotographer

Robert J. Vanderbei

2018 Sept 11

Amateur Astronomers Association of Princeton
Peyton Hall

http://www.princeton.edu/∼rvdb

Stars Have Various Colors

Here's a pair of binary stars...

Albireo...

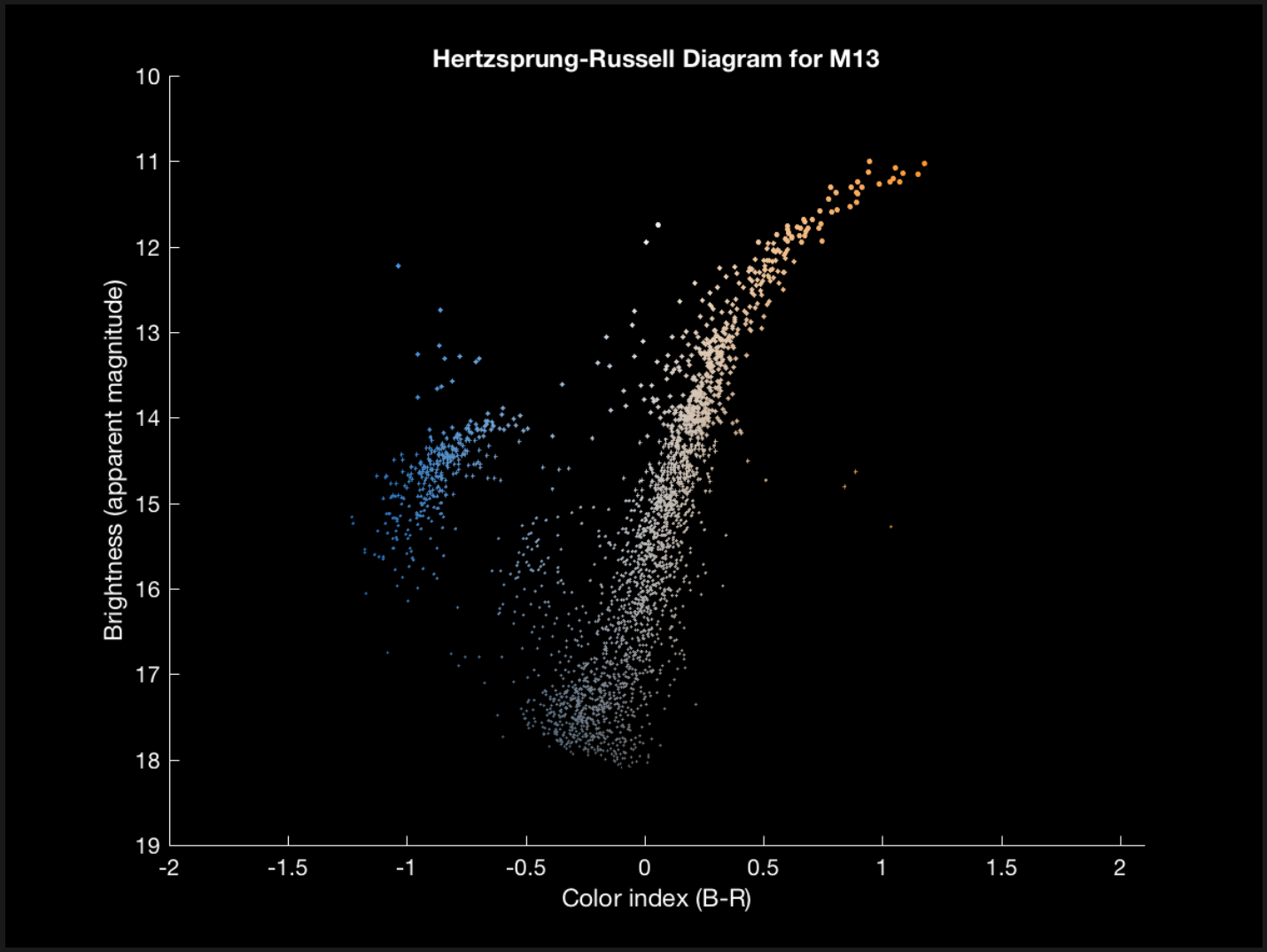
ϵ-Bootes...

The Coathanger asterism...

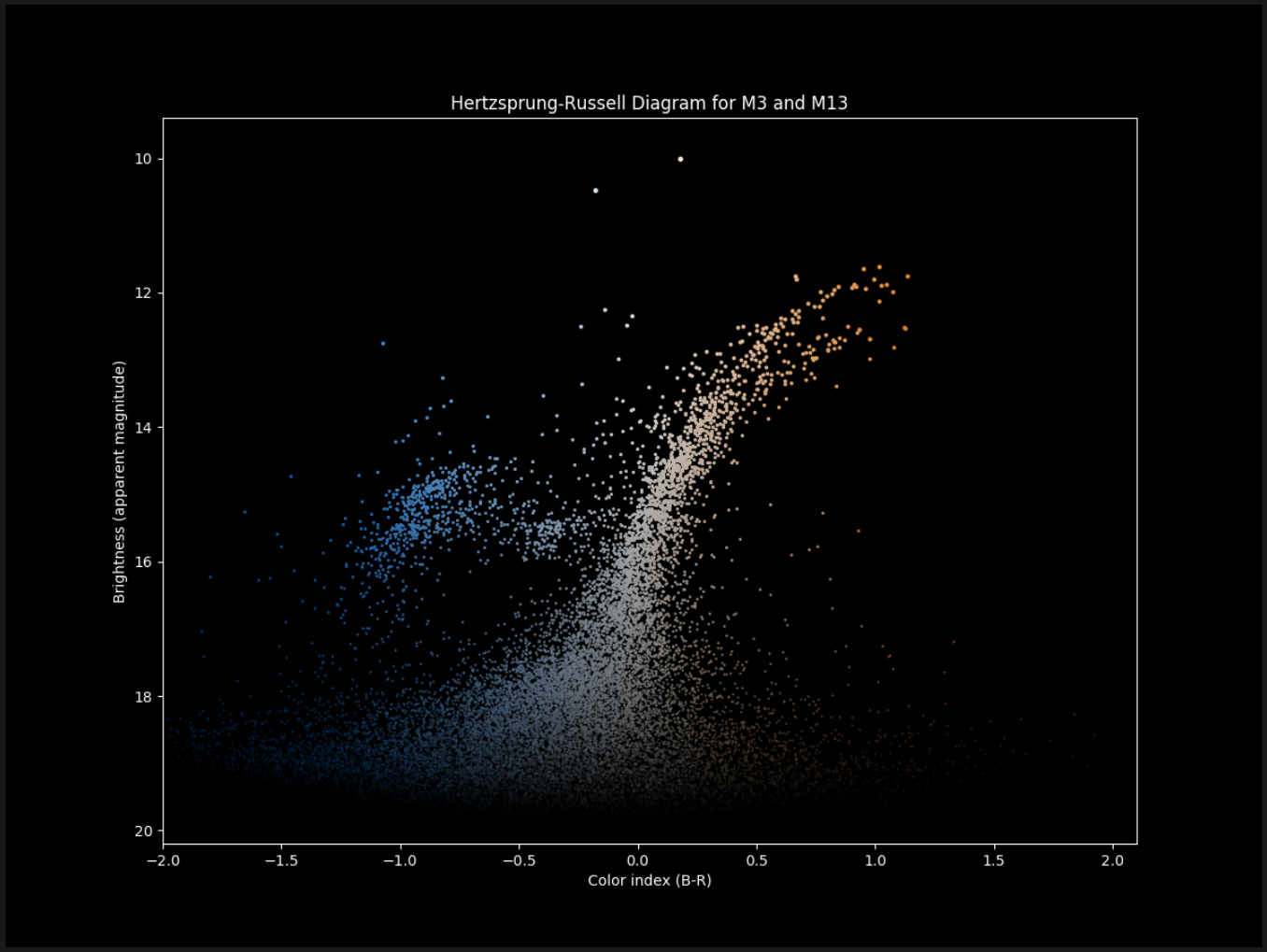
Open Cluster NGC 7789...

Globular Cluster M13...

Hertzsprung-Russell Diagram for M13

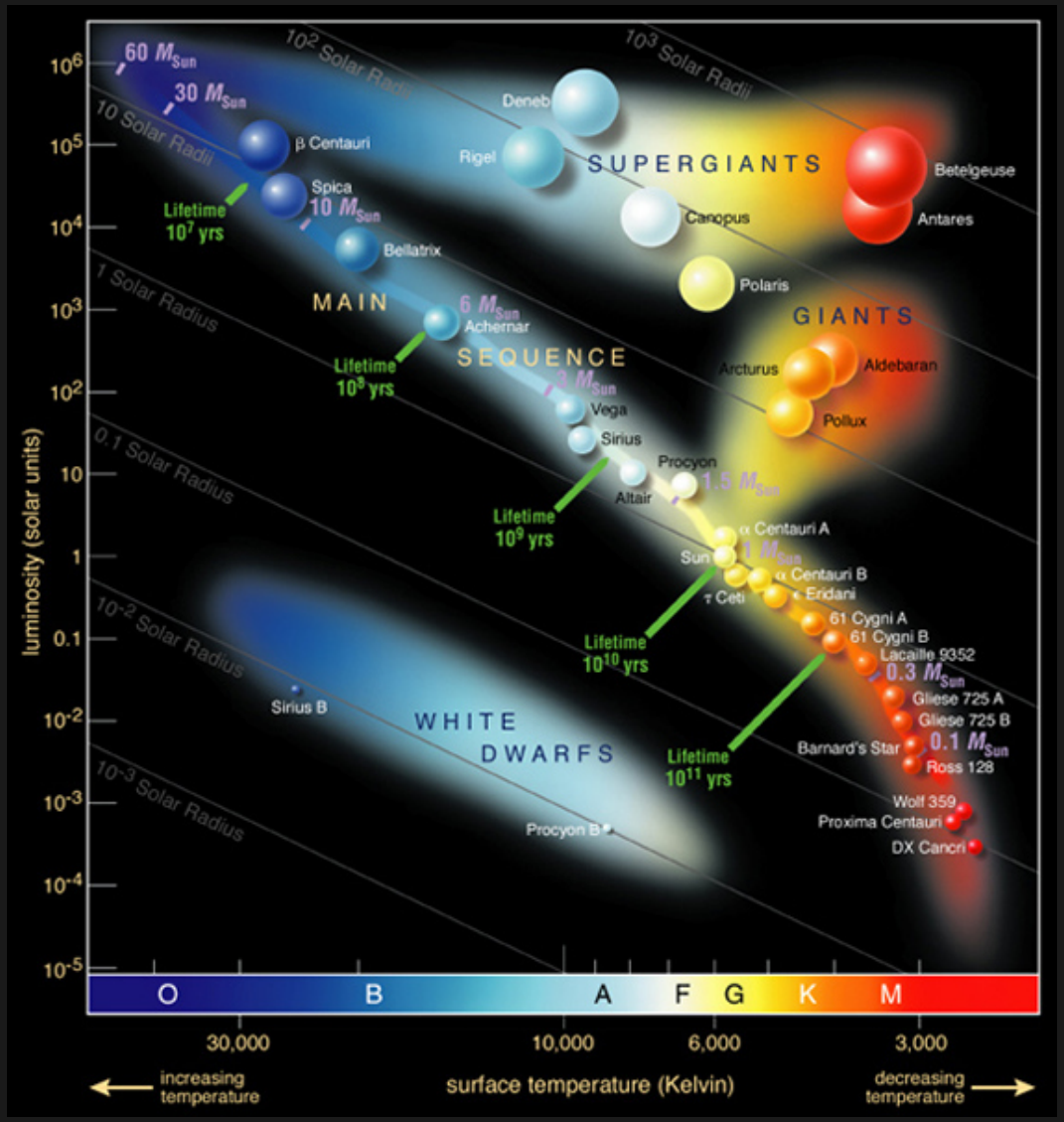


M3/M13 Comparison

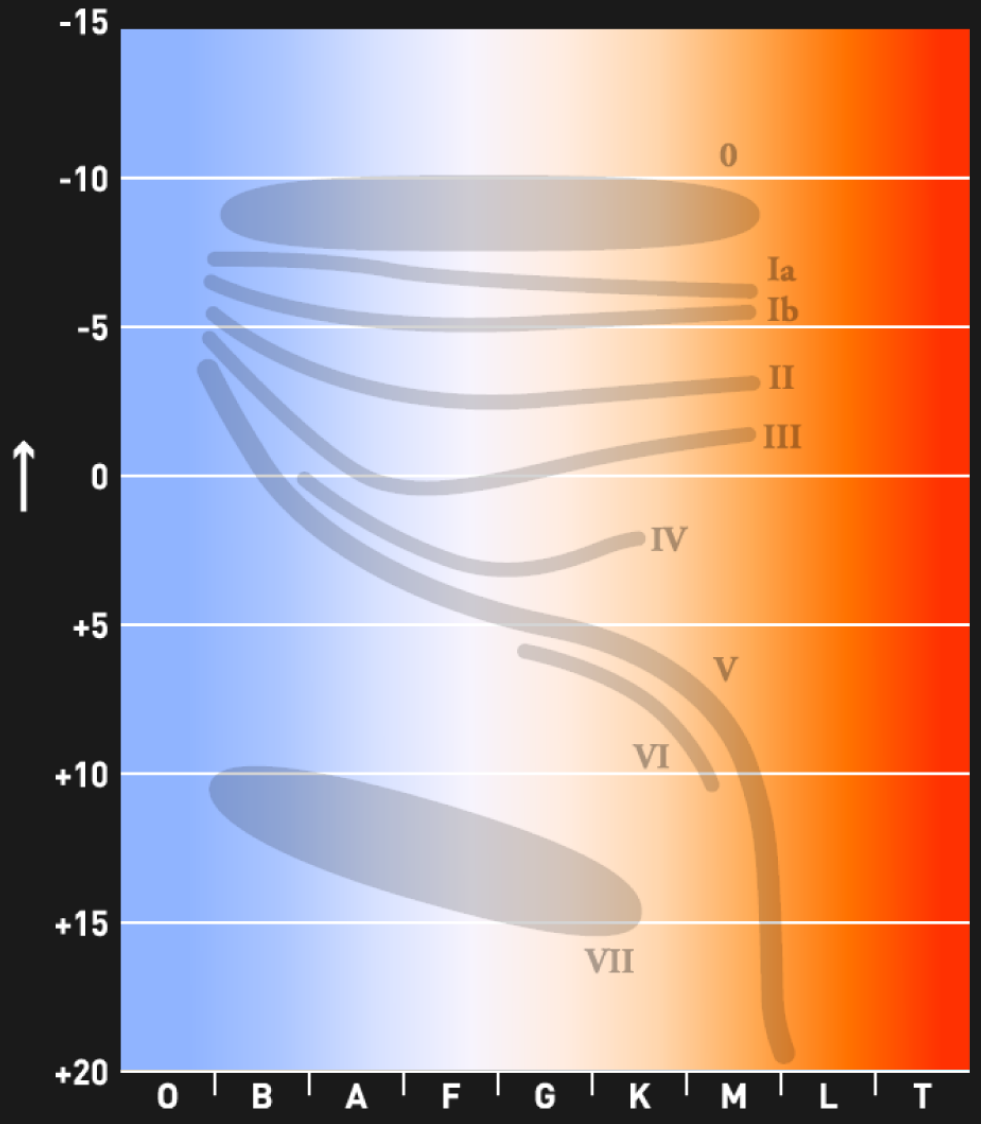


Brightness difference $= 0.7$ mag. Hence, relative distance... M3 is 1.38 times further away.

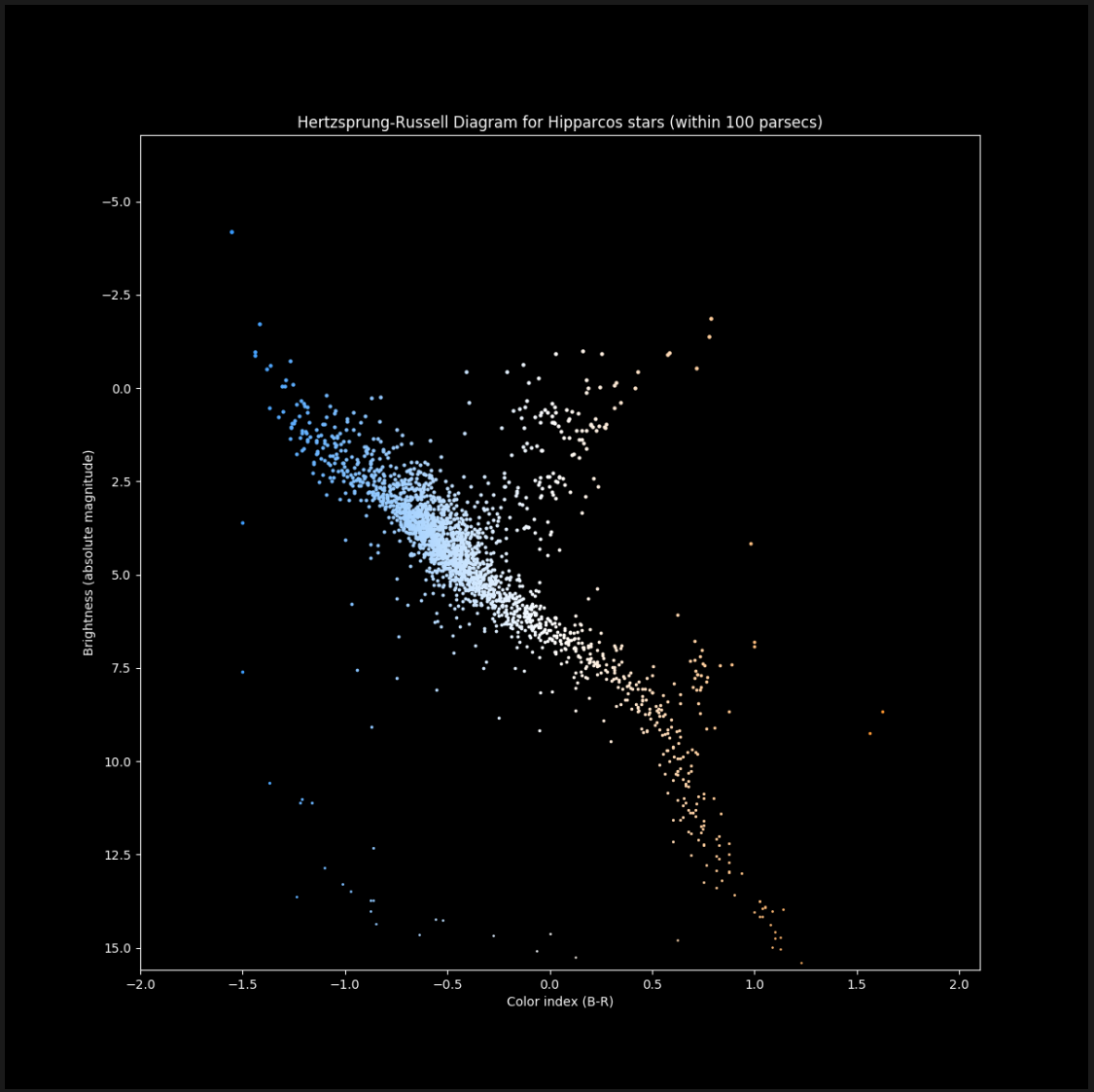
Hertzsprung-Russell Diagrams



Hertzsprung-Russell Diagrams

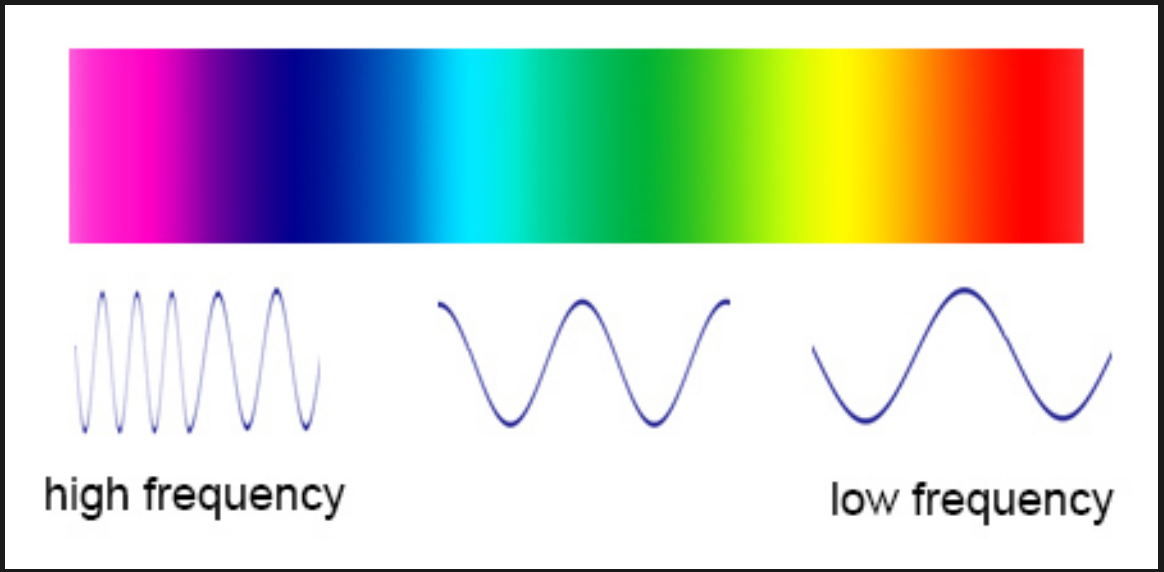


HR Diagram of Hipparcos Catalogue Stars

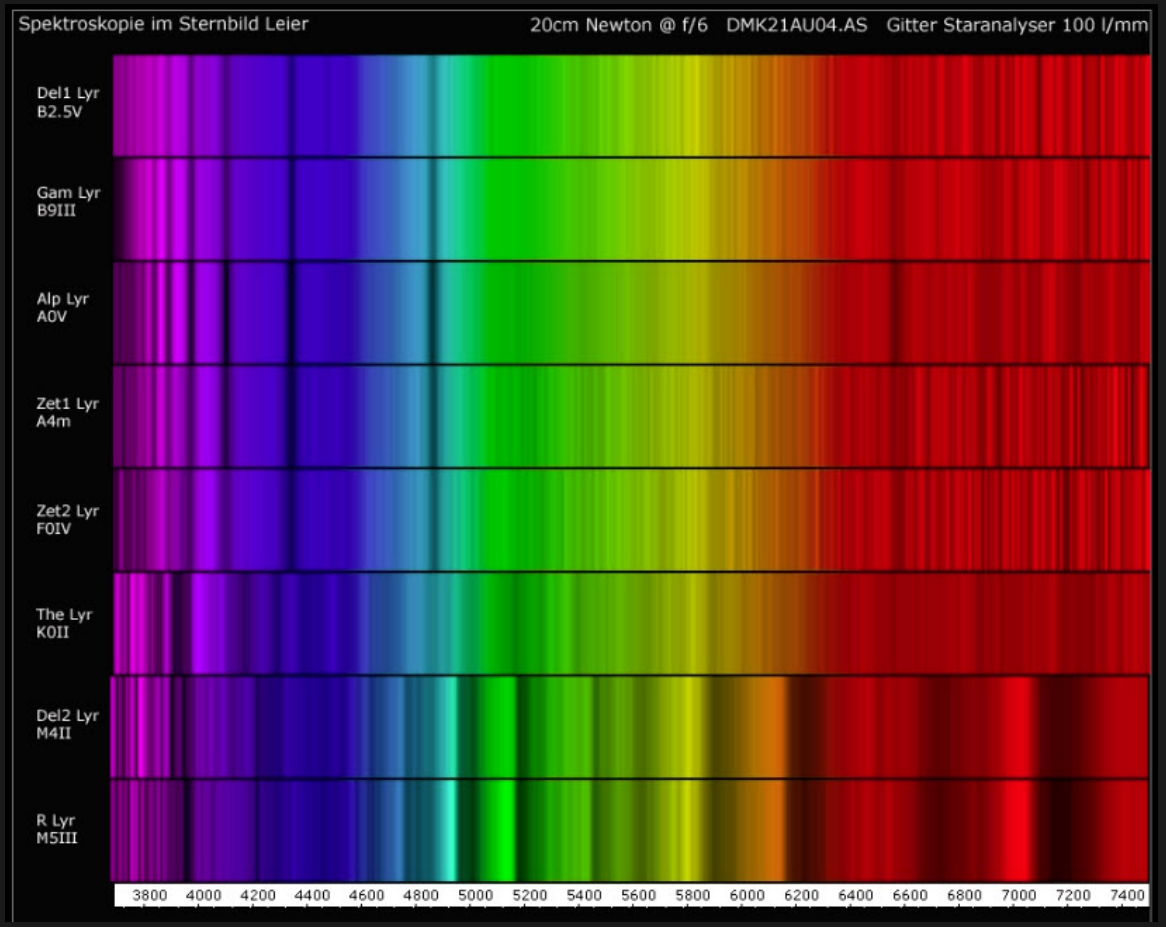


ROYGBIV

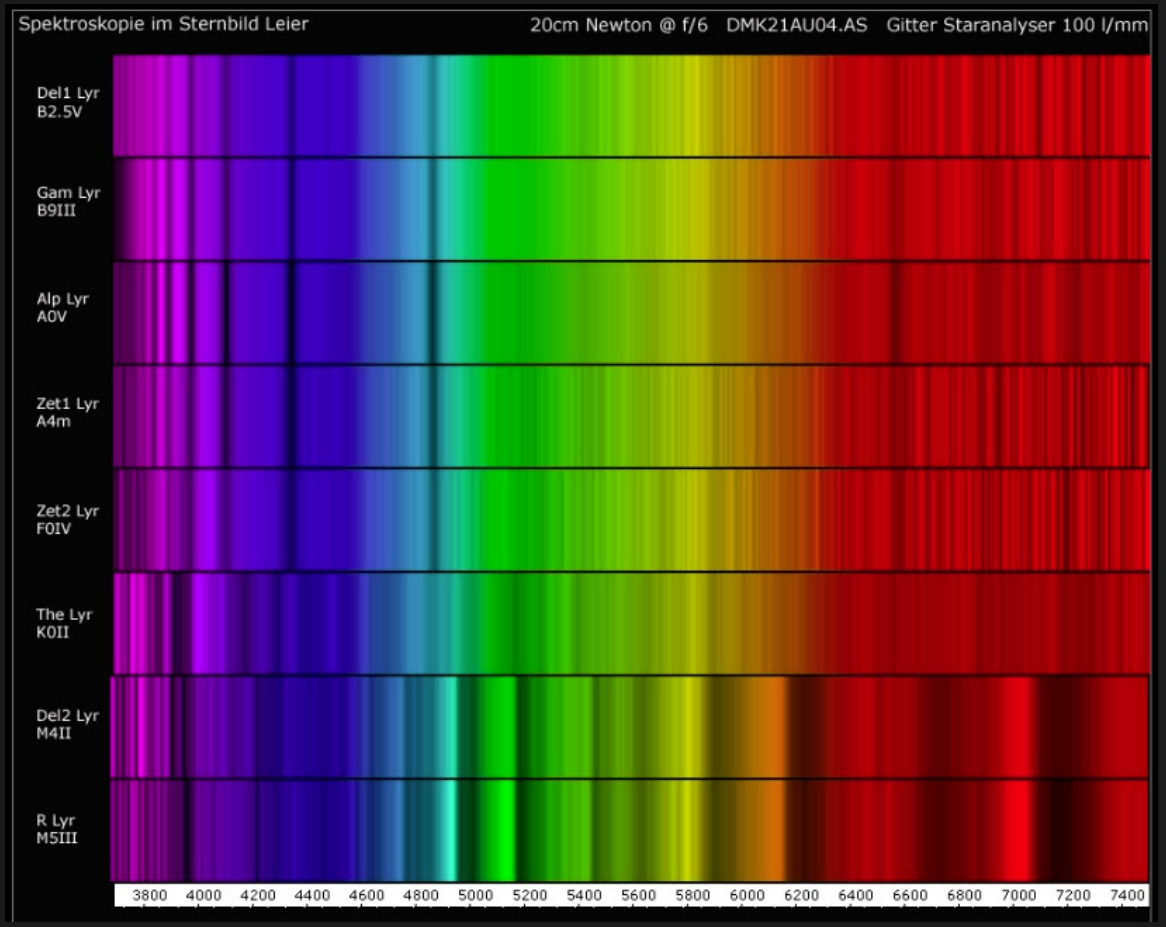
Red Orange Yellow Green Blue Indigo Violet



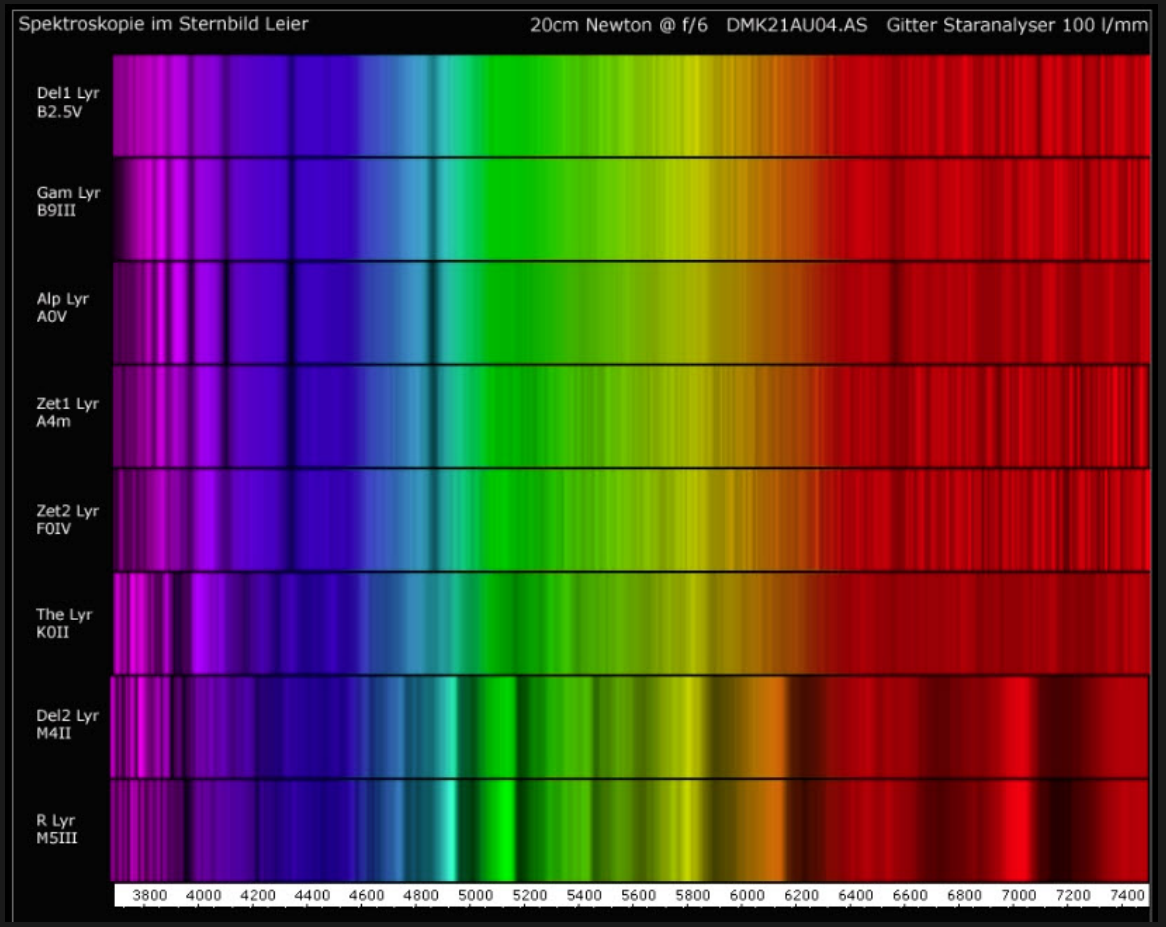
O B AF G K M


Spektroskopie im Sternbild Leier
20cm Newton @ f/6 DMK21AU04.AS Gitter Staranalyser 100 l/mm
Del1 Lyr
B2.5V
Gam Lyr
B9III
Alp Lyr
A0V
Zet1 Lyr
A4m
Zet2 Lyr
F0IV
The Lyr
K0II
Del2 Lyr
M4II
R Lyr
M5III
3800 4000 4200 4400 4600 4800 5000 5200 5400 5600 5800 6000 6200 6400 6600 6800 7000 7200 7400

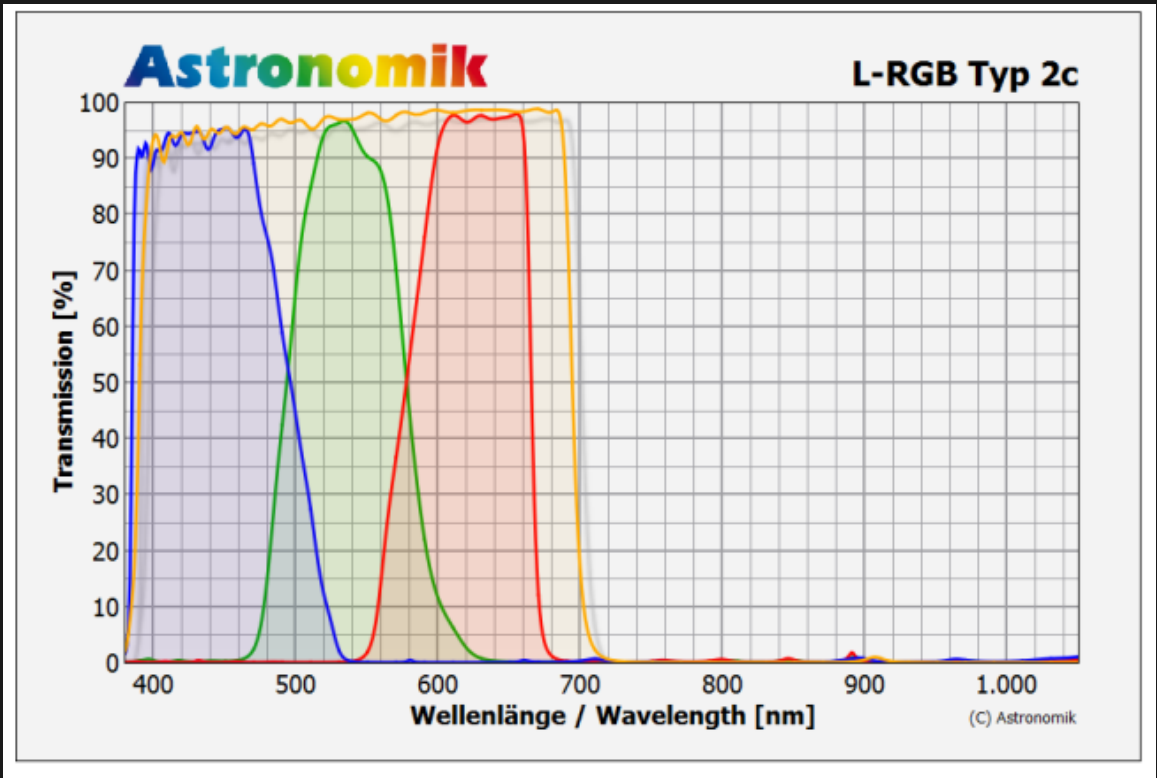
OhBeAFineGirlKissMe



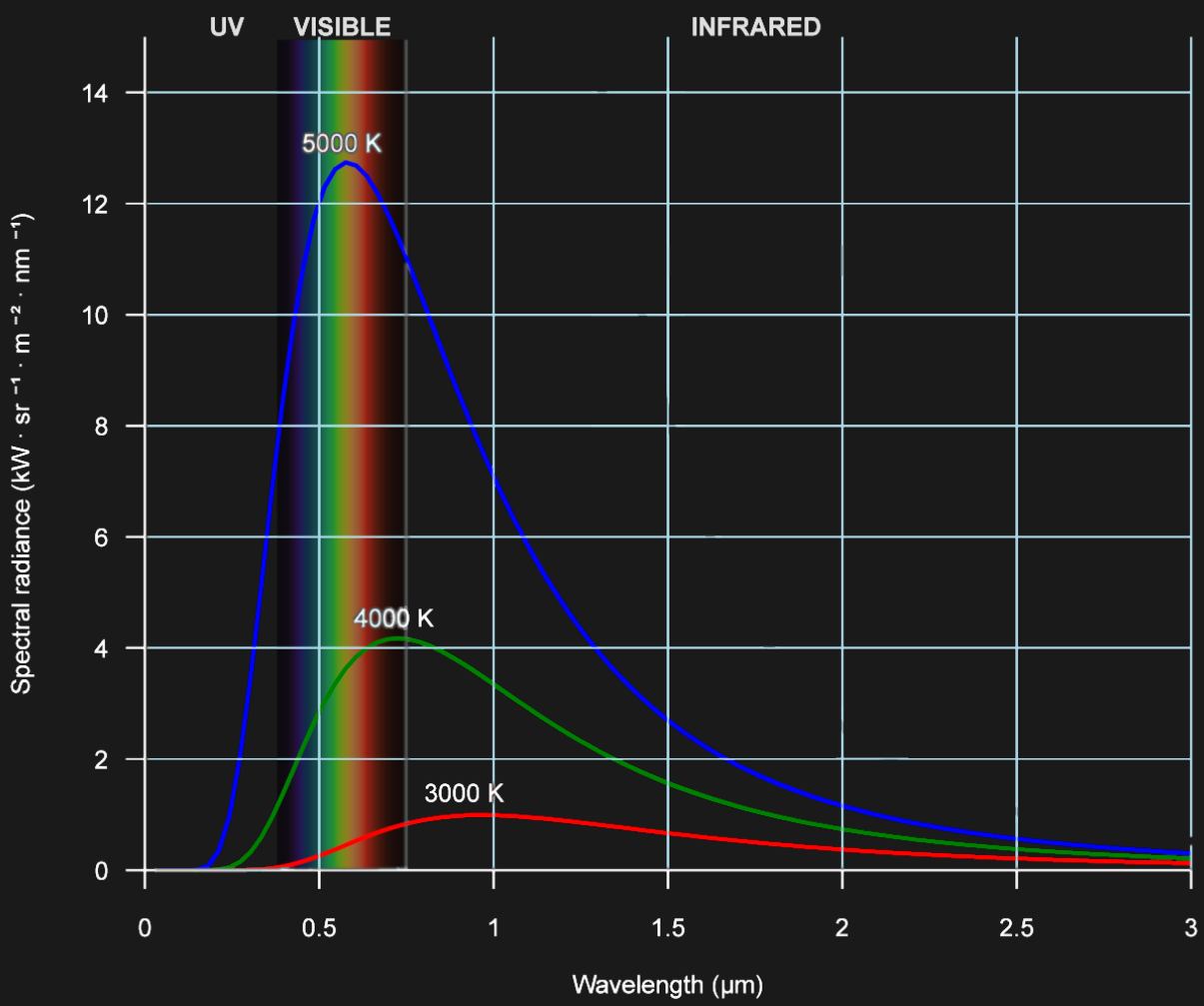
OhBeAFineGuyKissMe



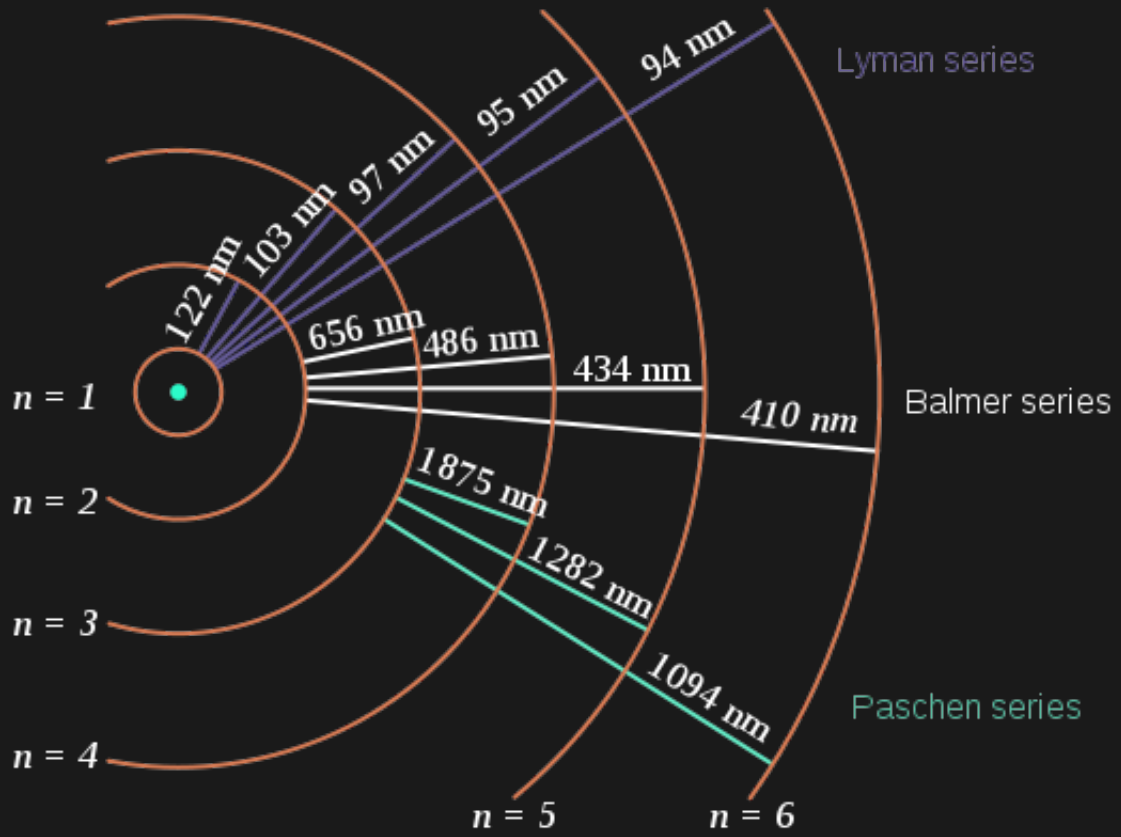
LRGB


Astronomik
L-RGB Typ 2c
Transmission [%]
100
90
80
70
60
50
40
30
20
10
0
400
500
600
700
800
900
1.000
Wellenlänge / Wavelength [nm]
(C) Astronomik

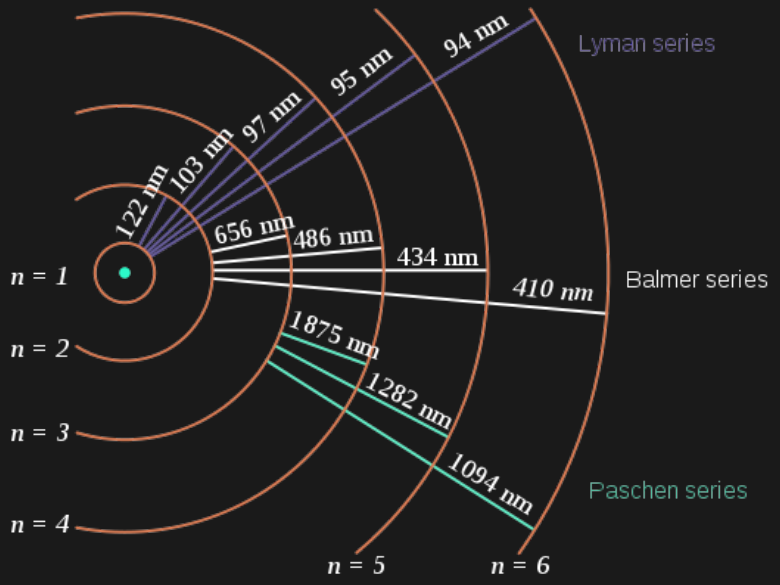
Black-body Radiation



Quantum Mechanics



Energy Levels



Energy E is inversely proportional to wavelength λ:

$$E = \frac{a}{\lambda}$$

From the diagram we see that

$$\begin{aligned} E_2 - E_1 &= \frac{a}{122} \\ E_3 - E_2 &= \frac{a}{656} \end{aligned}$$

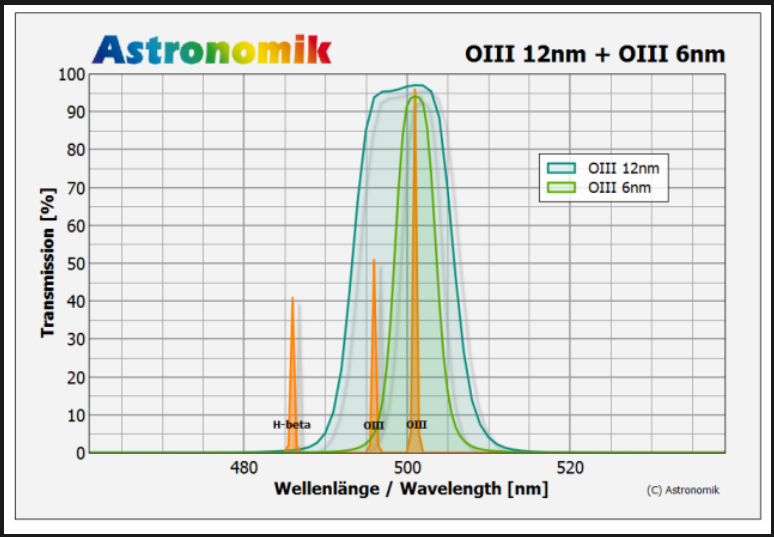
And so we can calculate

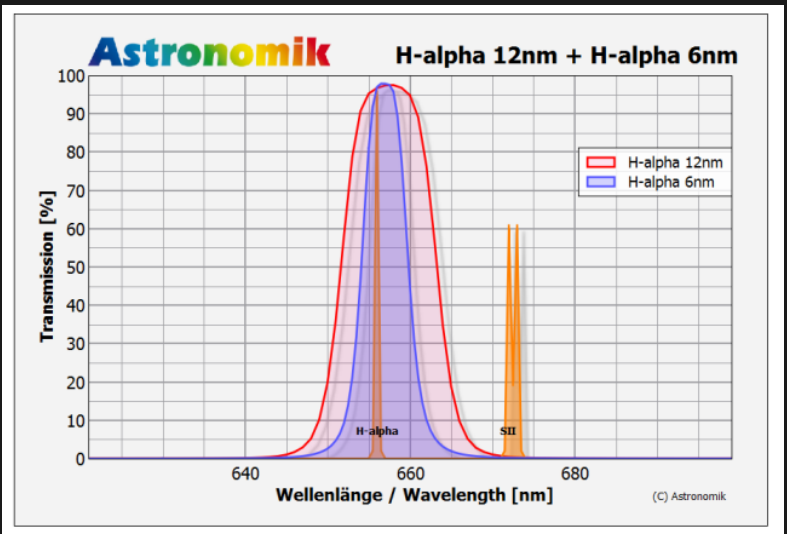
$$\begin{aligned} E_3 - E_1 &= (E_3 - E_2) + (E_2 - E_1) \\ &= \frac{a}{656} + \frac{a}{122} \\ &= a\frac{122 + 656}{122 * 656} \\ &= \frac{a}{102.9} \\ &\approx \frac{a}{103} \end{aligned}$$

NOTE: Energy is also inversely proportional to n^2:

$$E_n = -\frac{b}{n^2}$$

Hα, O-III


Astronomik
OIII 12nm + OIII 6nm
Transmission [%]
100
90
80
70
60
50
40
30
20
10
0
480
500
520
Wellenlänge / Wavelength [nm]
OIII 12nm
OIII 6nm
H-beta
OIII
OIII
(C) Astronomik

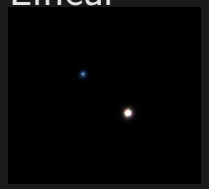

Astronomik
H-alpha 12nm + H-alpha 6nm
Transmission [%]
100
90
80
70
60
50
40
30
20
10
0
640
660
680
Wellenlänge / Wavelength [nm]
H-alpha 12nm
H-alpha 6nm
H-alpha
SII
(C) Astronomik

Diffraction Grating

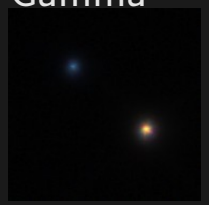
I recently bought a *Star Analyser 100* diffraction grating from RSpec Astro:

Albireo

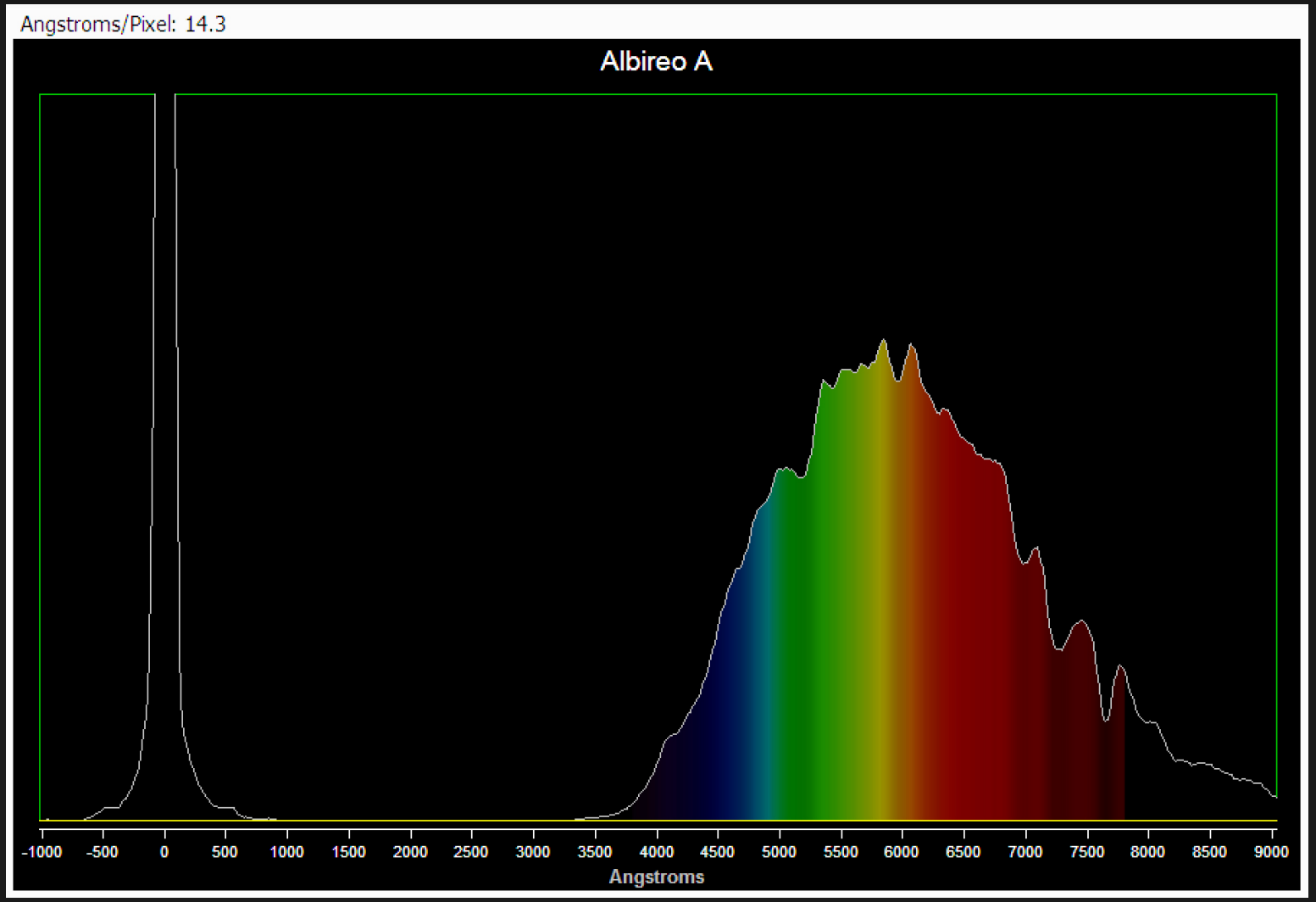
Linear



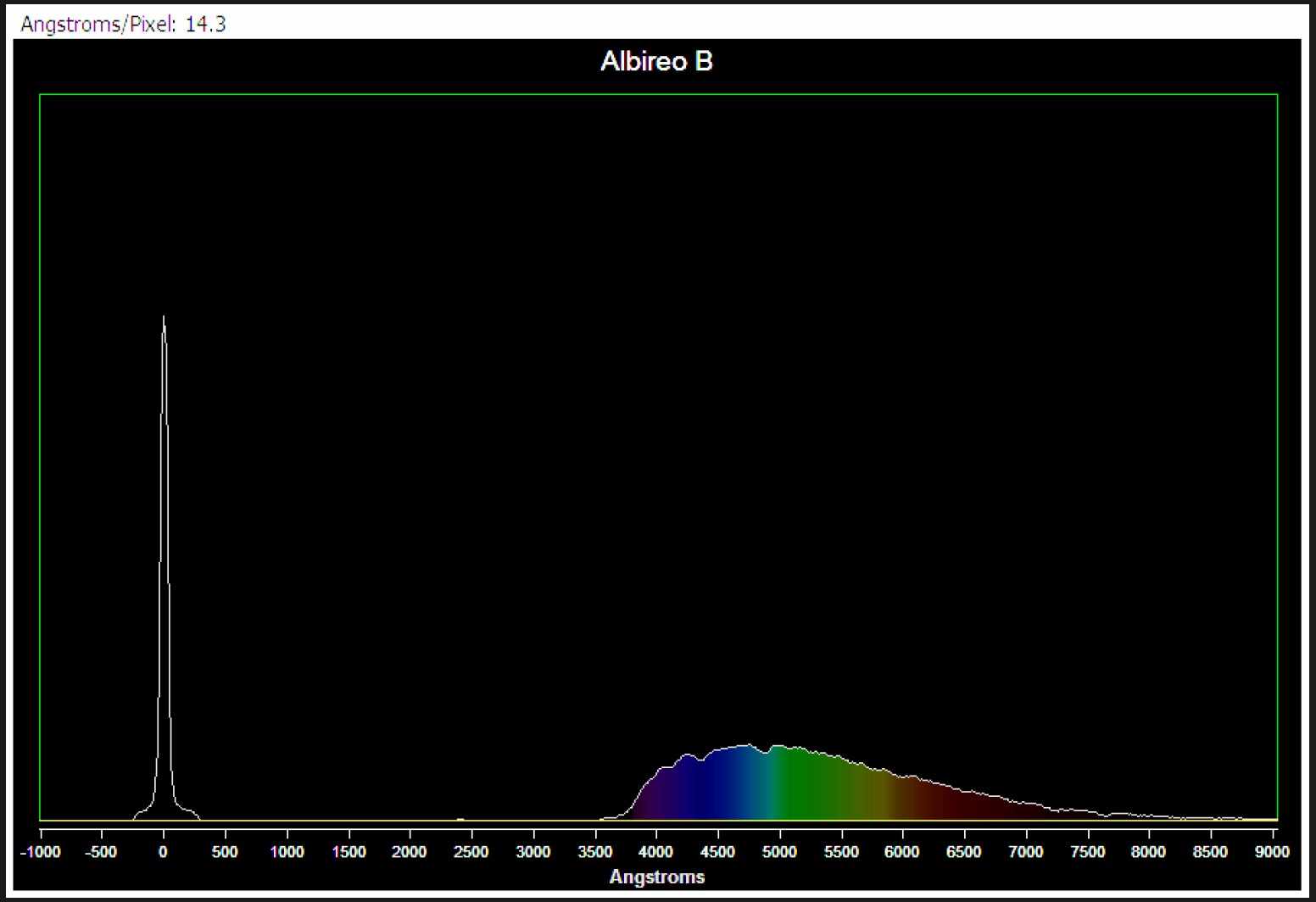
Gamma



Albireo A

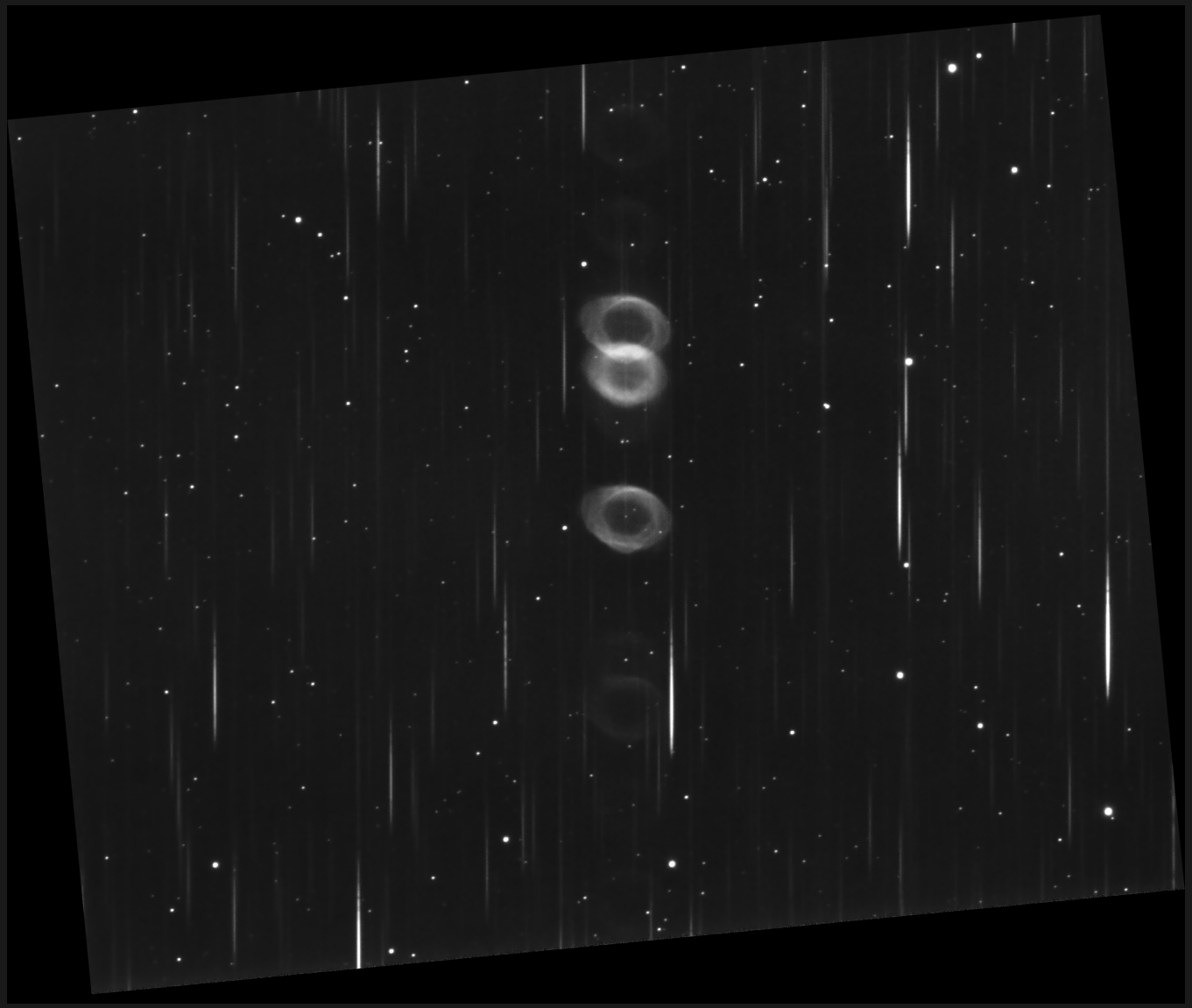

Angstroms/Pixel: 14.3
Albireo A
-1000
-500
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000
6500
7000
7500
8000
8500
9000
Angstroms

Albireo B


Angstroms/Pixel: 14.3
Albireo B
-1000
-500
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000
6500
7000
7500
8000
8500
9000
Angstroms

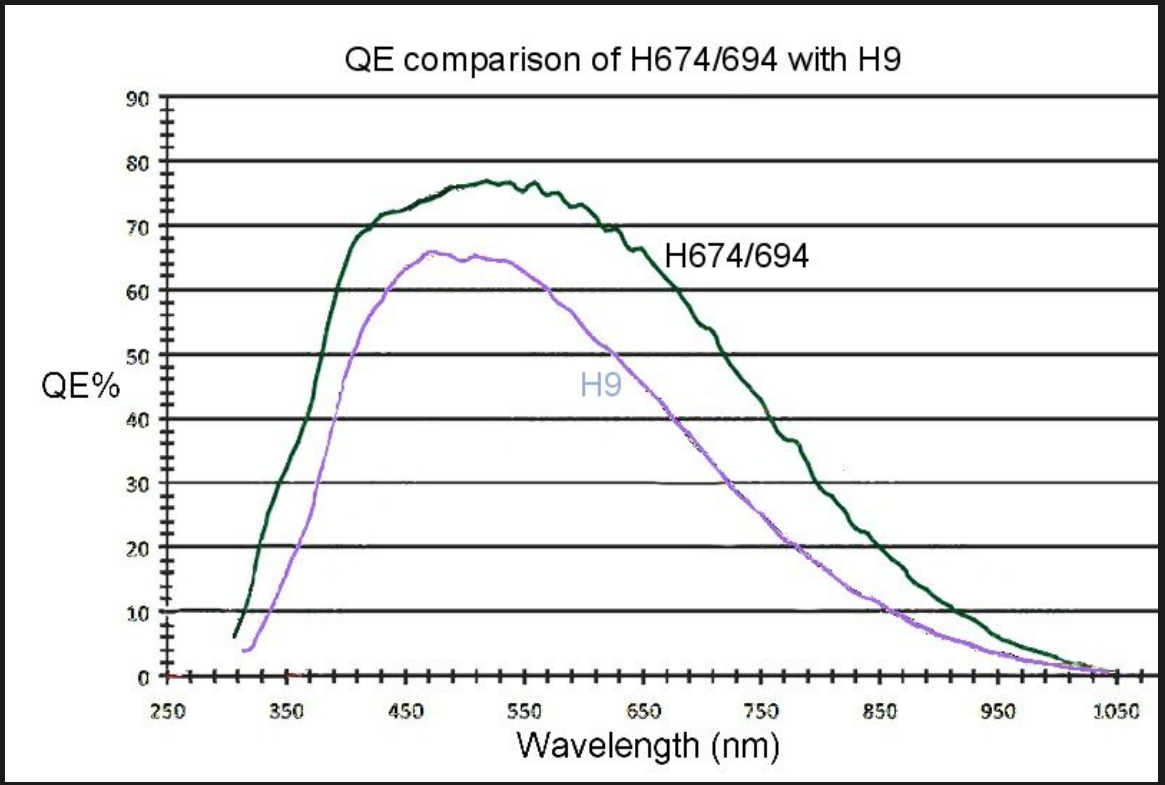
The Ring Nebula

The Ring Nebula

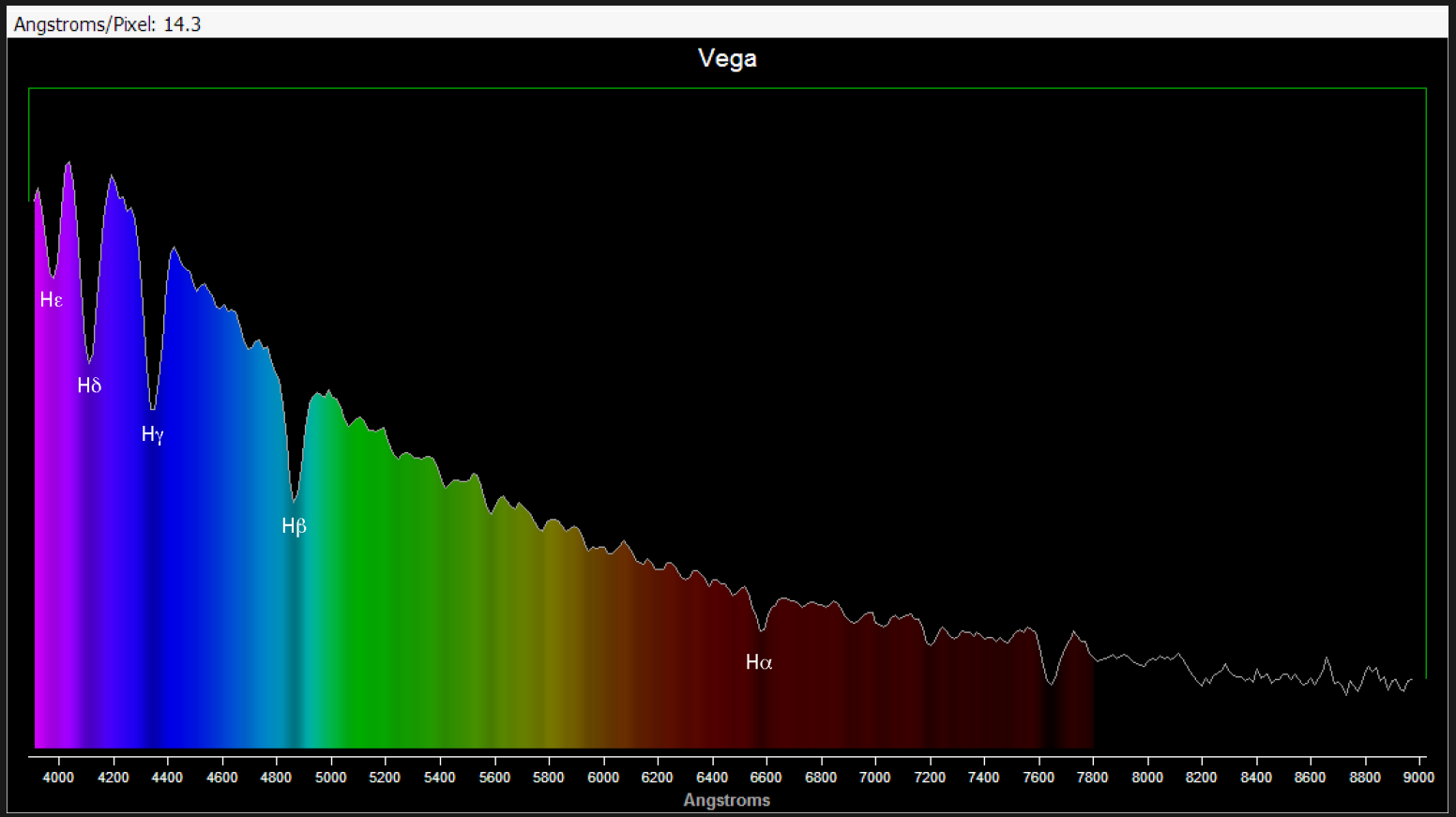


Camera Response Curve

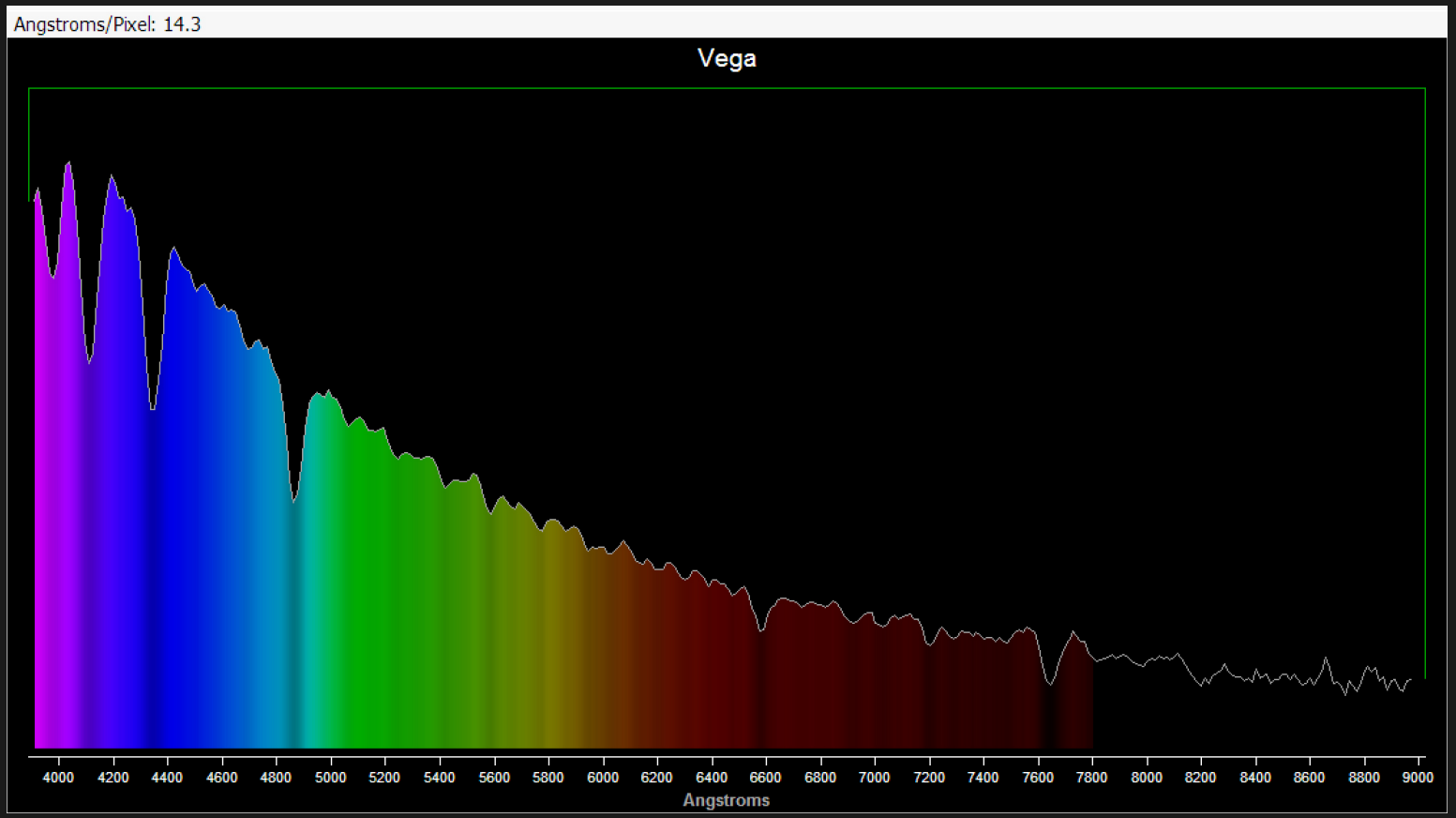
The RSpec software can automatically correct for the nonuniformity of a camera's sensitivity.



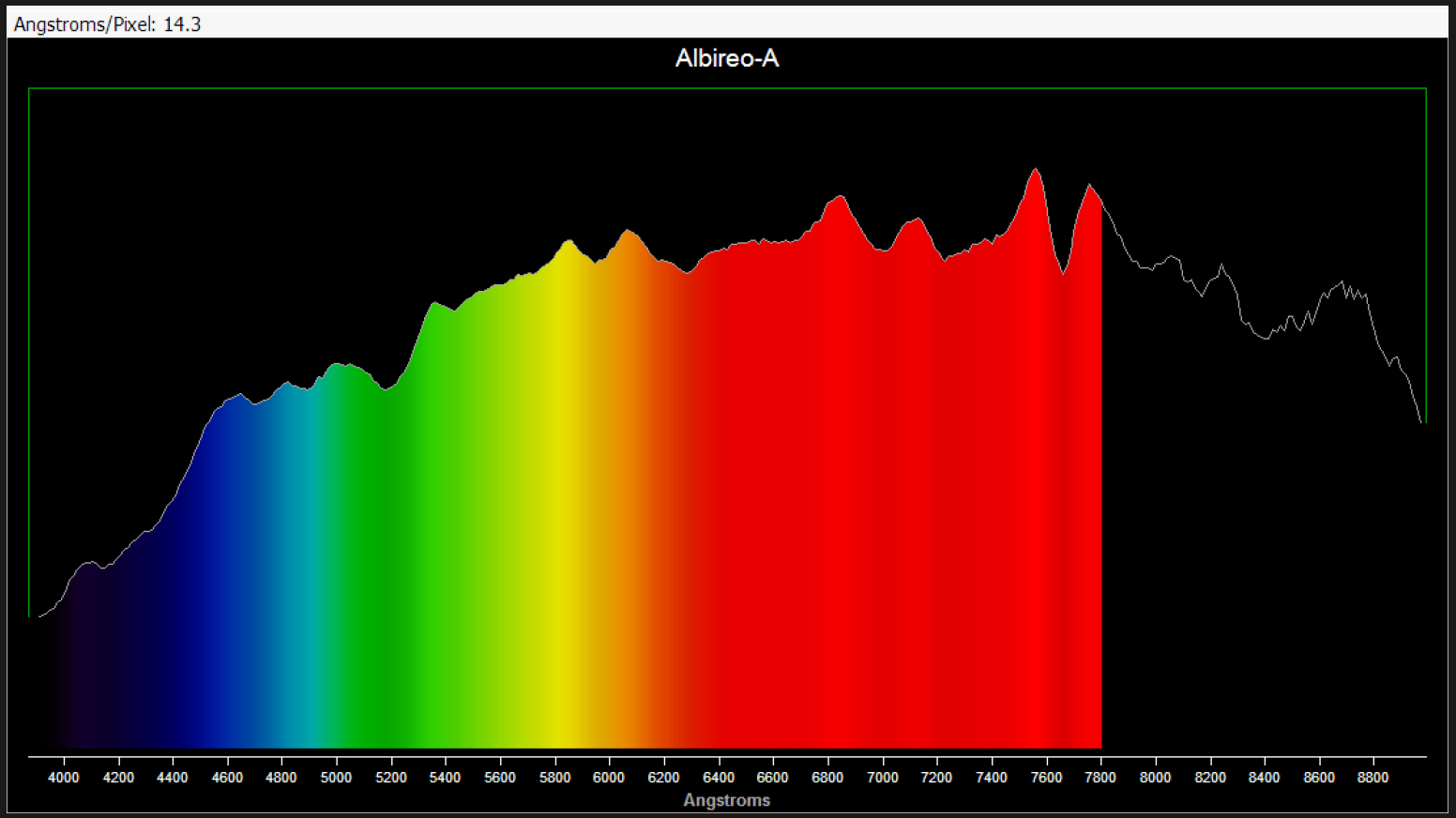
Vega


Angstroms/Pixel: 14.3
Vega
Hε
Hδ
Hγ
Hβ
Hα
4000 4200 4400 4600 4800 5000 5200 5400 5600 5800 6000 6200 6400 6600 6800 7000 7200 7400 7600 7800 8000 8200 8400 8600 8800 9000
Angstroms

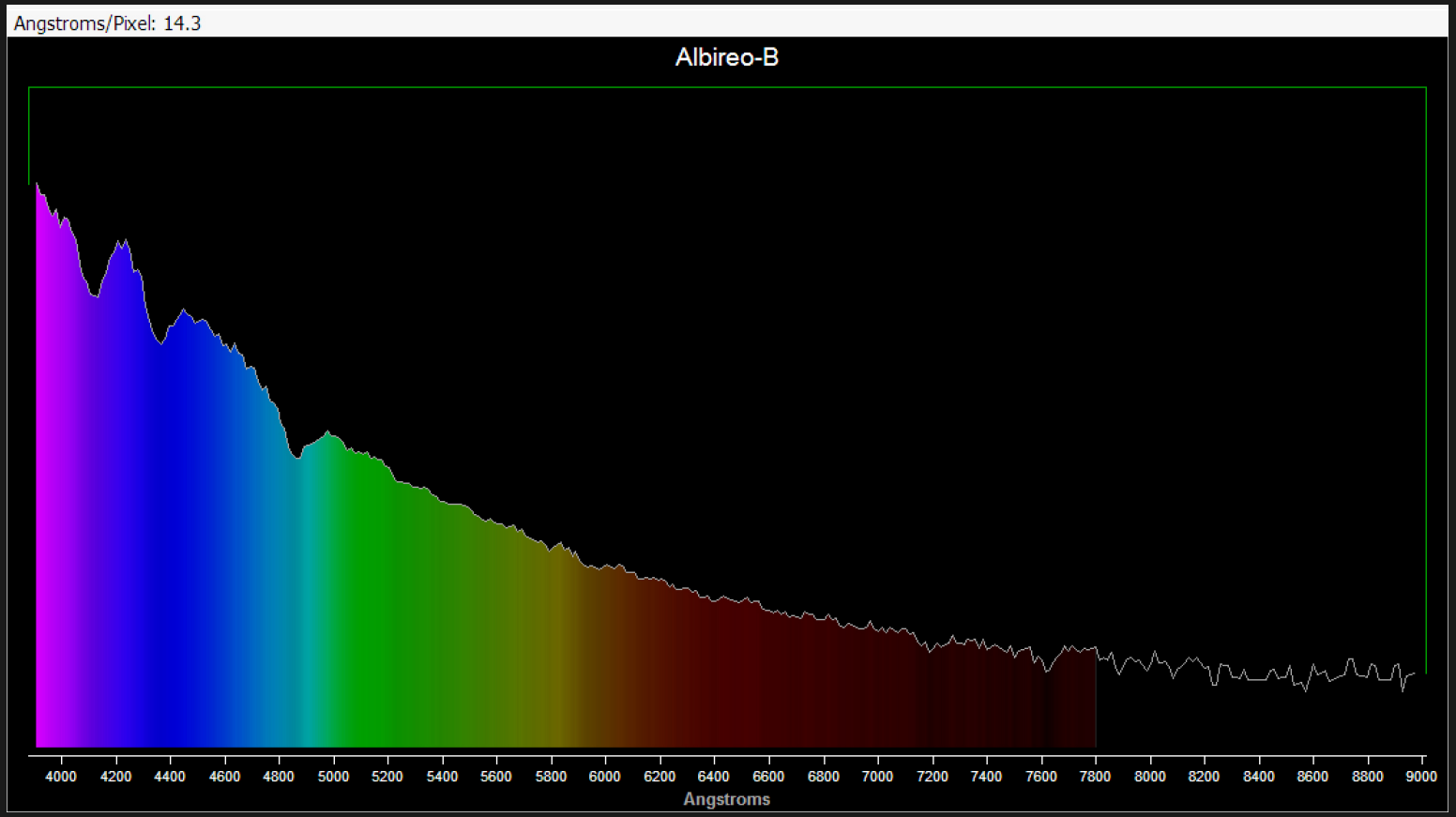
Vega


Angstroms/Pixel: 14.3
Vega
4000
4200
4400
4600
4800
5000
5200
5400
5600
5800
6000
6200
6400
6600
6800
7000
7200
7400
7600
7800
8000
8200
8400
8600
8800
9000
Angstroms

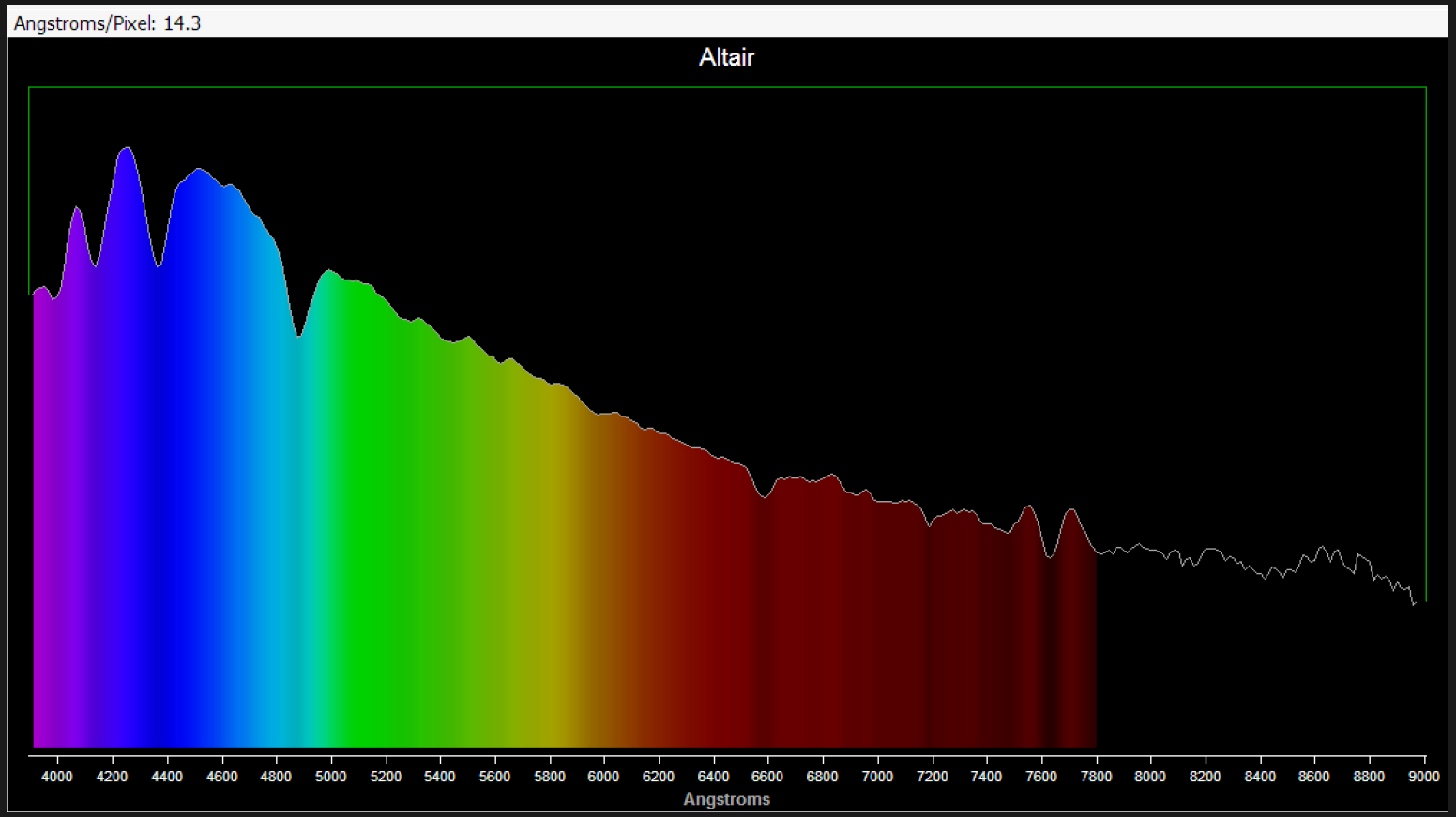
Albireo A


Angstroms/Pixel: 14.3
Albireo-A
4000
4200
4400
4600
4800
5000
5200
5400
5600
5800
6000
6200
6400
6600
6800
7000
7200
7400
7600
7800
8000
8200
8400
8600
8800
Angstroms

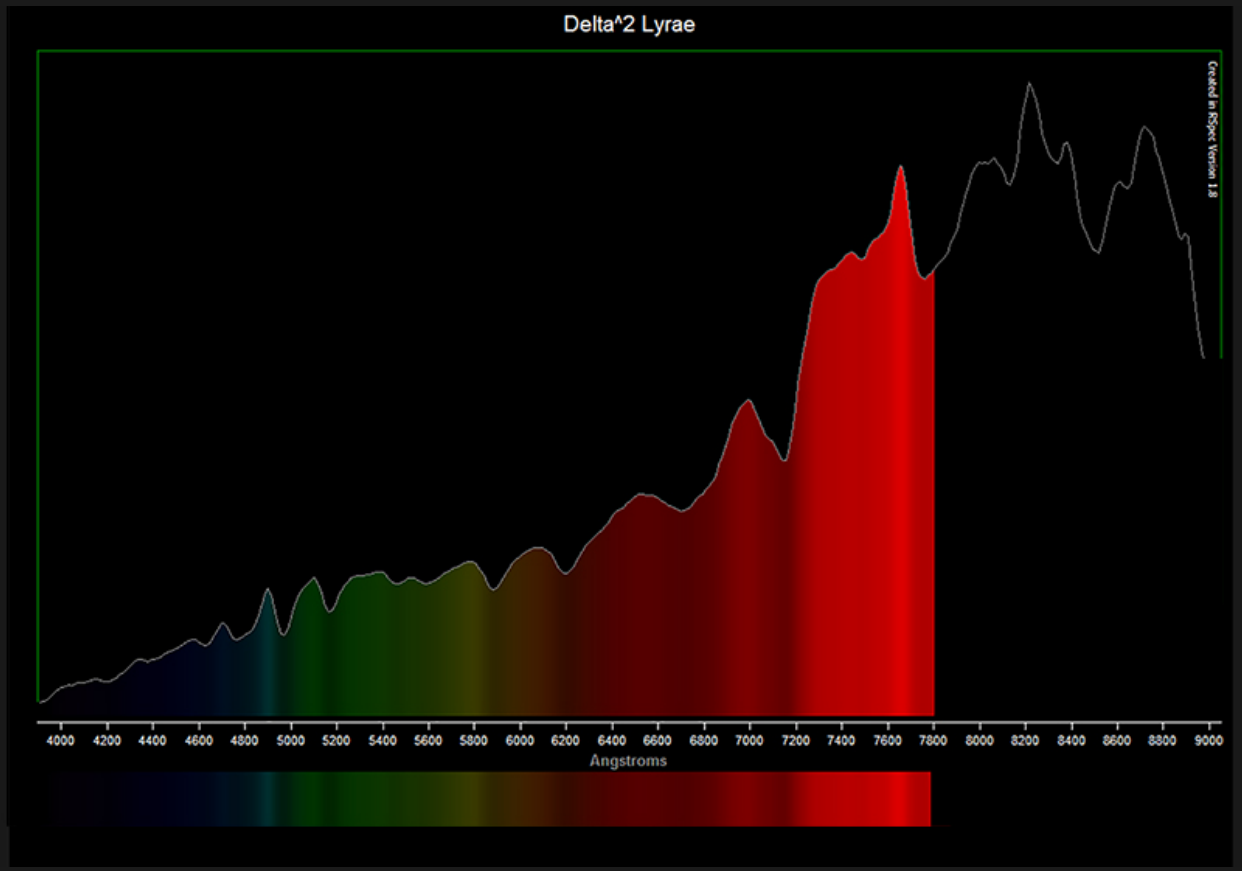
Albireo B


Angstroms/Pixel: 14.3
Albireo-B
4000
4200
4400
4600
4800
5000
5200
5400
5600
5800
6000
6200
6400
6600
6800
7000
7200
7400
7600
7800
8000
8200
8400
8600
8800
9000
Angstroms

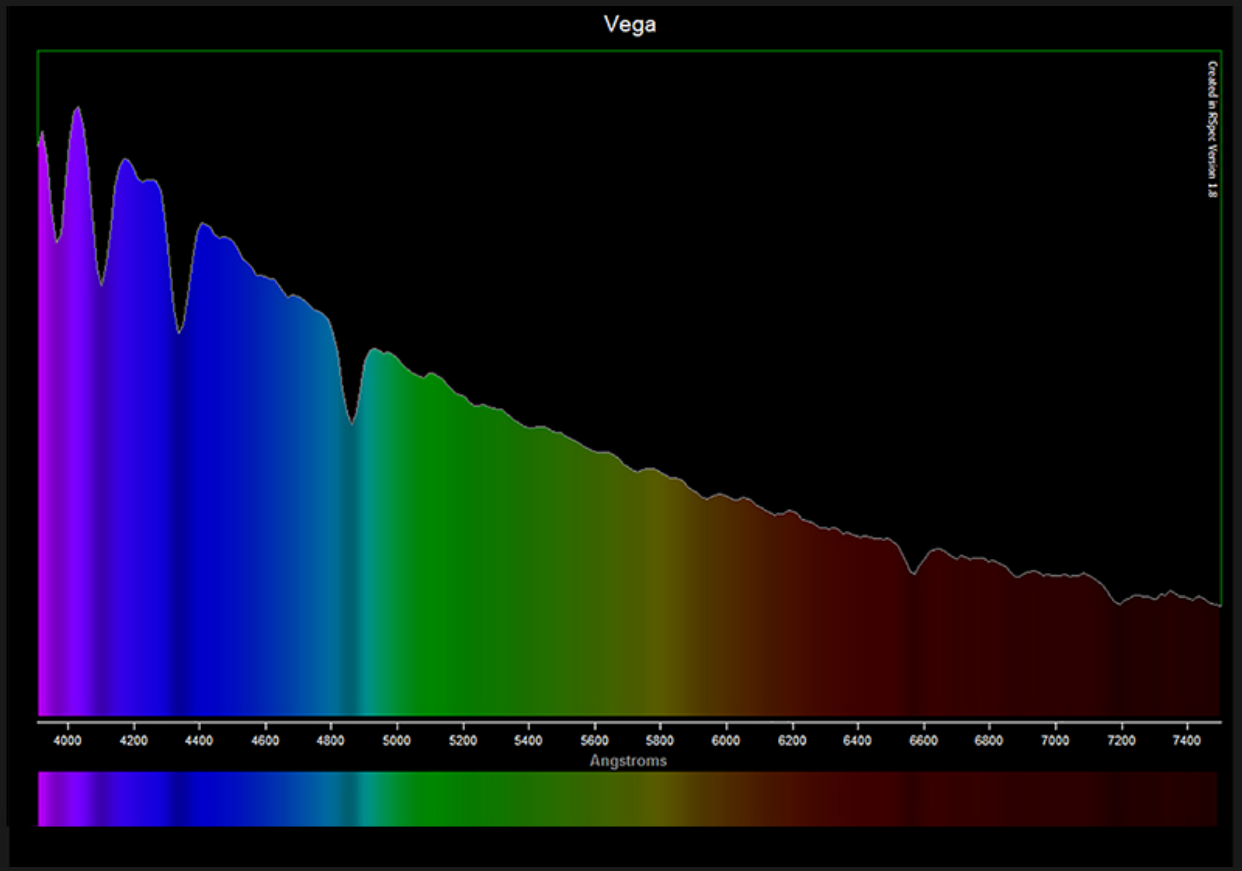
Altair


Angstroms/Pixel: 14.3
Altair
4000
4200
4400
4600
4800
5000
5200
5400
5600
5800
6000
6200
6400
6600
6800
7000
7200
7400
7600
7800
8000
8200
8400
8600
8800
9000
Angstroms

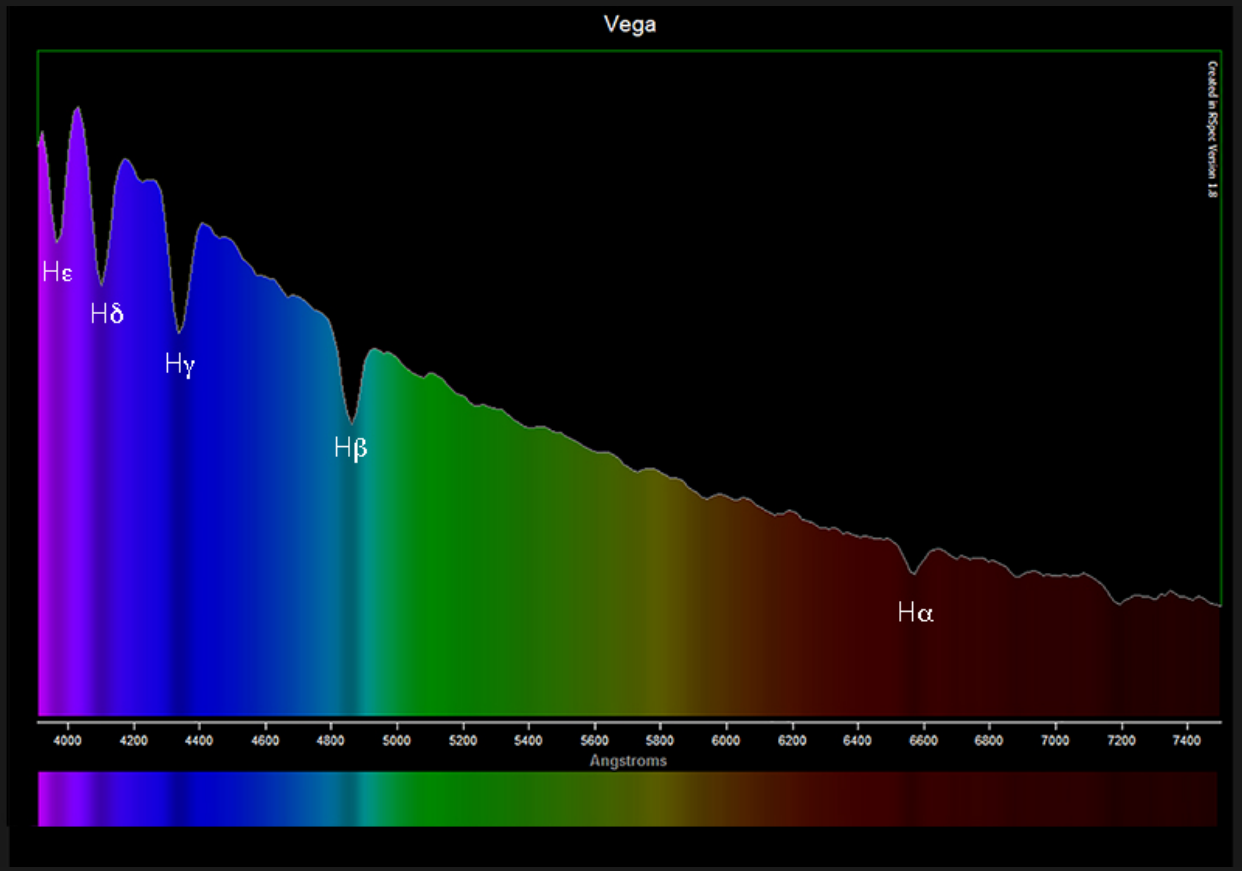
δ^2-Lyrae



Vega Again


Vega
Created in RSpec Version 1.8
4000
4200
4400
4600
4800
5000
5200
5400
5600
5800
6000
6200
6400
6600
6800
7000
7200
7400
Angstroms

Vega Again


Vega
Created in RSpec Version 1.8
Hε
Hδ
Hγ
Hβ
Hα
4000
4200
4400
4600
4800
5000
5200
5400
5600
5800
6000
6200
6400
6600
6800
7000
7200
7400
Angstroms

Quasar Redshift

Quasar Markarian 501

Quasar Markarian 501 Spectrum