

Astronomical Spectroscopy Introduction PMO 2014



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Astronomical Spectroscopy

Astrophysics

Quantum Mechanics

Electromagnetic spectrum
provides insight to the universe

Instrumentation

Software

Astronomical Spectroscopy

Analyzing Electromagnetic Spectrum

☉ Composition

- ☉ Spectra line patterns: atoms, ions & molecules

☉ Temperature & density

- ☉ Spectra line patterns: atom states & transitions
- ☉ Stellar classification

☉ Motions

- ☉ Spectra line Doppler shift

Astronomical Spectroscopy

Analyzing Electromagnetic Spectrum

- Abundance
 - Spectra line strengths
- Pressure
 - Spectra line profile
- Magnetic fields
 - Spectra line splits

Electromagnetic Waves

$$c = v\lambda$$

- 👁️ c : speed of light ($\sim 3 \times 10^8$ meters/sec)
- 👁️ v : frequency (Hz)
- 👁️ λ : wavelength (meters)
- 👁️ Frequency increases ($v \uparrow$), wavelength decreases ($\lambda \downarrow$)

Electromagnetic Waves Energy

$$E = h\nu$$

- ☉ E: energy of a photon
 - ☉ 1 electronvolt (1eV) = 1.602×10^{-19} Joules
- ☉ h: Planck's constant (6.626×10^{-34} Joule seconds)
- ☉ ν : frequency (Hz)
- ☉ Frequency increases ($\nu \uparrow$), energy increases ($E \uparrow$)

Electromagnetic Waves Energy

Wavelength increases ($\lambda \uparrow$), energy decreases ($E \downarrow$)

UV

λ nm	λ Å	E Joules	eV
300	3000	6.62E-19	4.13
350	3500	5.67E-19	3.54
400	4000	4.97E-19	3.10
450	4500	4.41E-19	2.75
500	5000	3.97E-19	2.48
550	5500	3.61E-19	2.25
600	6000	3.31E-19	2.07
650	6500	3.06E-19	1.91
700	7000	2.84E-19	1.77
750	7500	2.65E-19	1.65

IR

$$E = h\nu$$

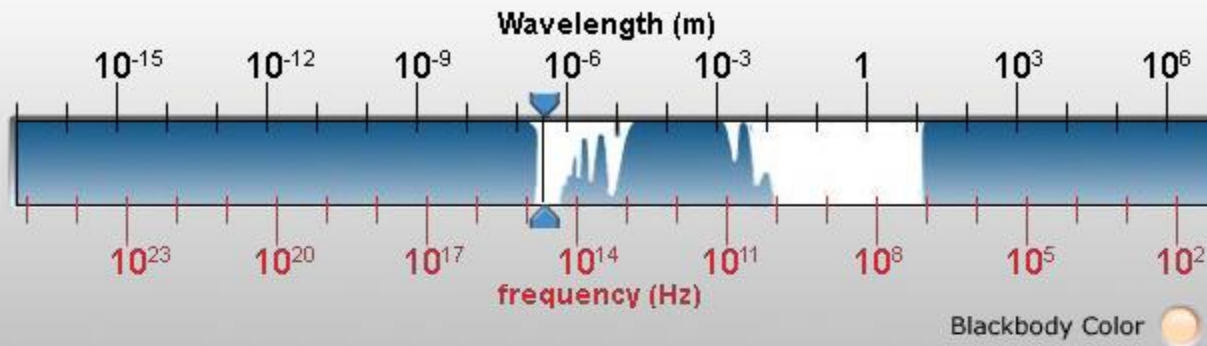
$$\nu = c/\lambda$$

$$E = hc/\lambda$$

$$1\text{eV} = 1.602 \times 10^{-19} \text{ Joules}$$

Electromagnetic Spectrum

Credit <http://astro.unl.edu>



Spectrum Screen

Wavelength = 6.600×10^{-7} m

Visible

Frequency = 4.545×10^{14} Hz

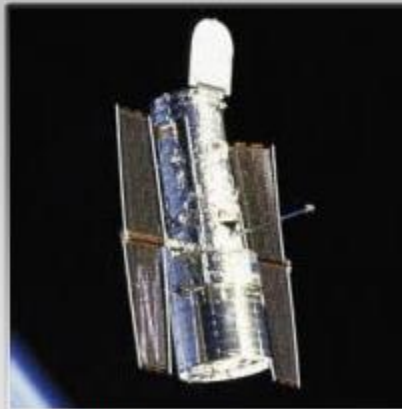
$E = h * f = 3.000 \times 10^{-19}$ Joule

Size



Dust

Instrument



Hubble Space Telescope

Astronomy Picture



Visual Image of Spiral Galaxy M51

Wien's Displacement Law

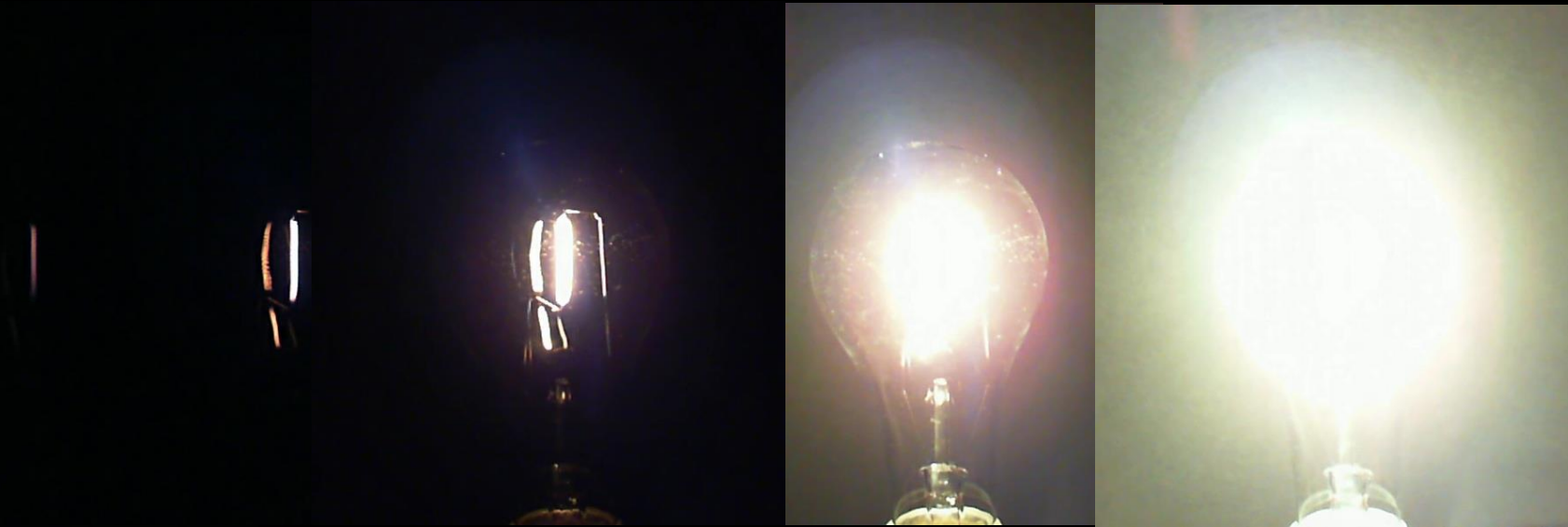
$$\lambda_{\max} = b/T$$

- ☉ λ_{\max} : Peak emission at wavelength
- ☉ b : Wien's displacement constant
 - ☉ $2.8977 \times 10^{-3} \text{ m}\cdot\text{K}$
- ☉ T : temperature in Kelvin
 - ☉ Kelvin = C + 273
 - ☉ F = (C 9/5) + 32

Kelvin	C	F	Notes
0	-273	-459.4	Absolute Zero
273	0	32.0	Water Freezes
293	20	68.0	
373	100	212.0	Water Boils
798	525	977.0	Draper Point
1000	727	1340.6	Emits Red
6000	5727	10340.6	Emits White

Black Body Radiation

Varying the power to a light bulb



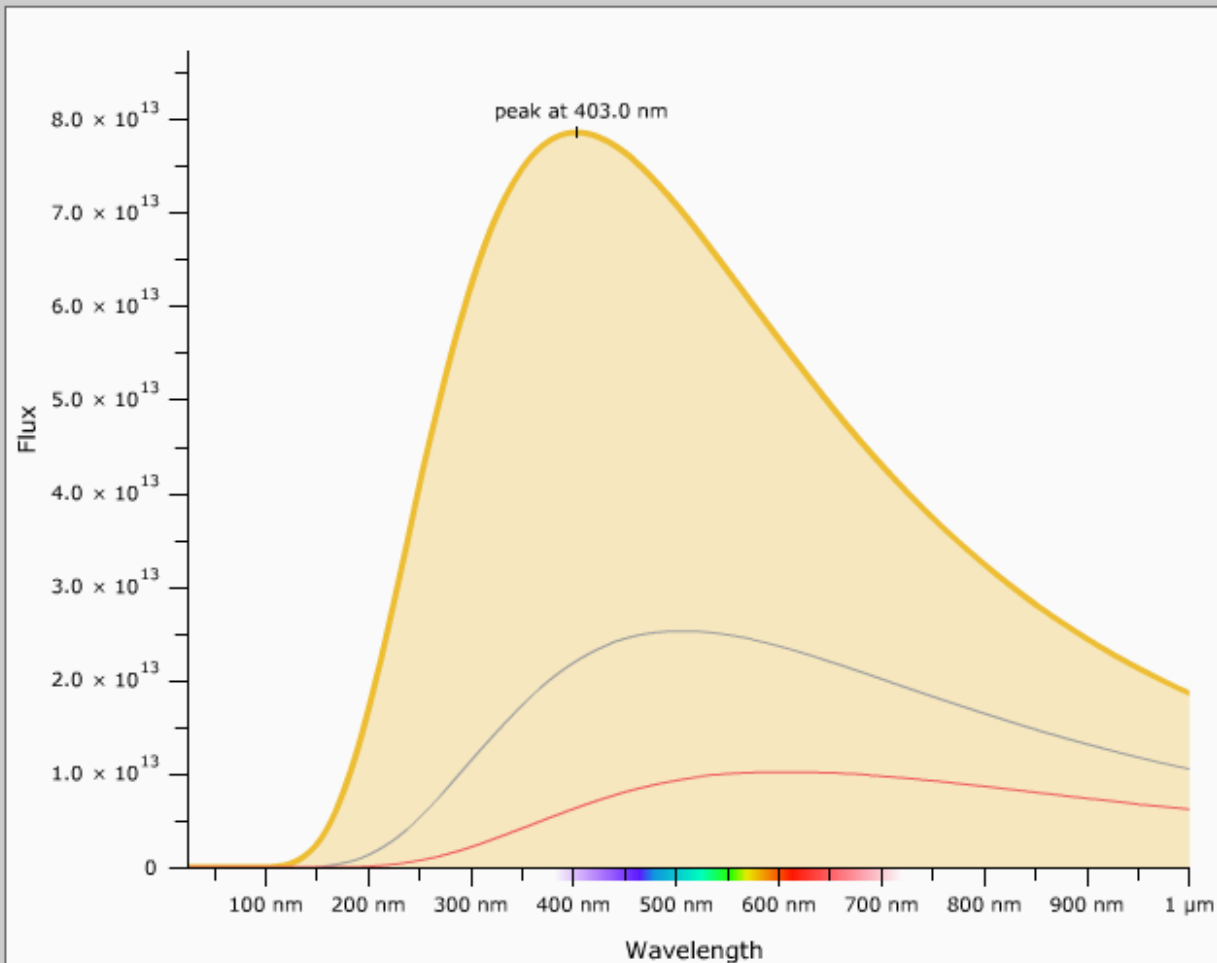
Black-Body Radiation

7190 K & Peak at 403.0 nm

Blackbody Curves and Filters Explorer

Credit <http://astro.unl.edu>

reset help about



curves filters

temperature: K



highlight area under curve

indicate peak wavelength

peak
temperature wavelength area under curve

●	7190 K	403.0 nm	$1.52 \times 10^8 \text{ W/m}^2$
●	5730 K	505.7 nm	$6.11 \times 10^7 \text{ W/m}^2$
●	4780 K	606.2 nm	$2.96 \times 10^7 \text{ W/m}^2$

add curve

remove curve

vertical scale horizontal scale

- lock scale
- autoscale to all curves
- autoscale to selected curve

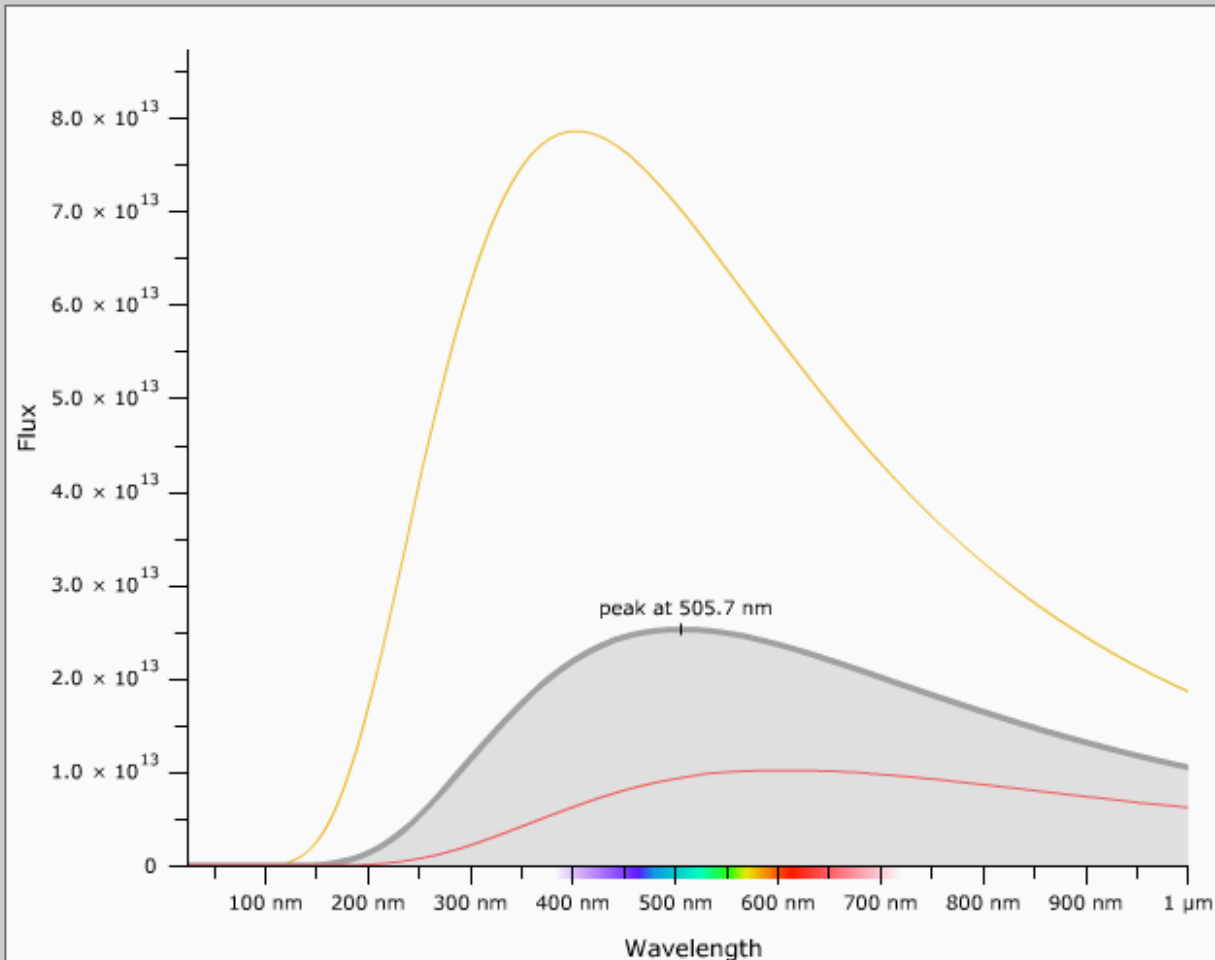
Black-Body Radiation

5730 K & Peak at 505.7 nm

Blackbody Curves and Filters Explorer

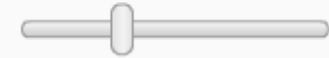
Credit <http://astro.unl.edu>

reset help about



curves filters

temperature: K



highlight area under curve

indicate peak wavelength

peak
temperature wavelength area under curve

●	7190 K	403.0 nm	$1.52 \times 10^8 \text{ W/m}^2$
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●	4780 K	606.2 nm	$2.96 \times 10^7 \text{ W/m}^2$

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remove curve

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- lock scale
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- autoscale to selected curve

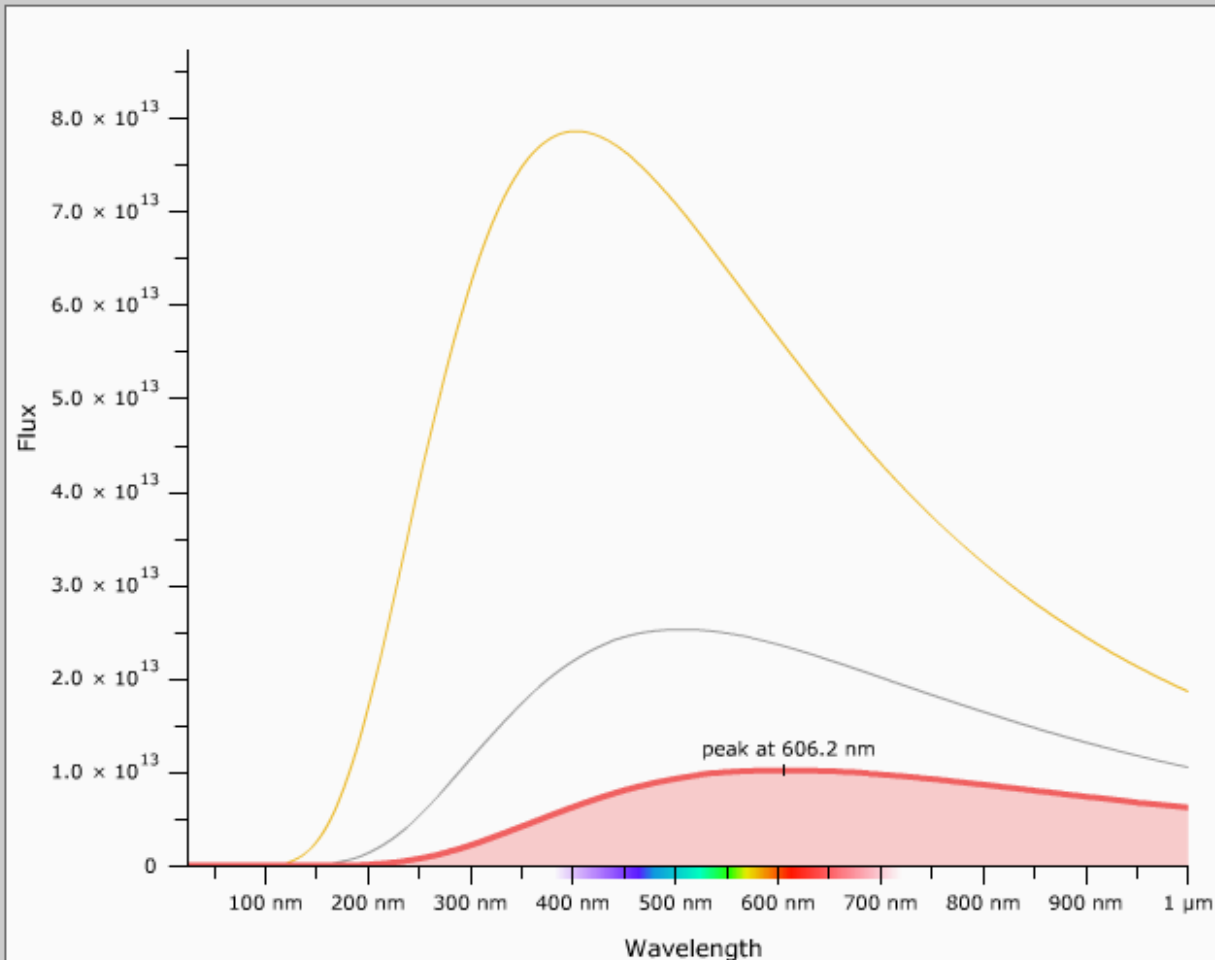
Black-Body Radiation

4780 K & Peak at 606.2 nm

Blackbody Curves and Filters Explorer

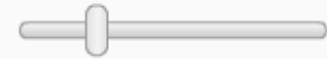
Credit <http://astro.unl.edu>

reset help about



curves filters

temperature: K



highlight area under curve

indicate peak wavelength

peak
temperature wavelength area under curve

●	7190 K	403.0 nm	1.52×10^8 W/m ²
●	5730 K	505.7 nm	6.11×10^7 W/m ²
●	4780 K	606.2 nm	2.96×10^7 W/m ²

add curve

remove curve

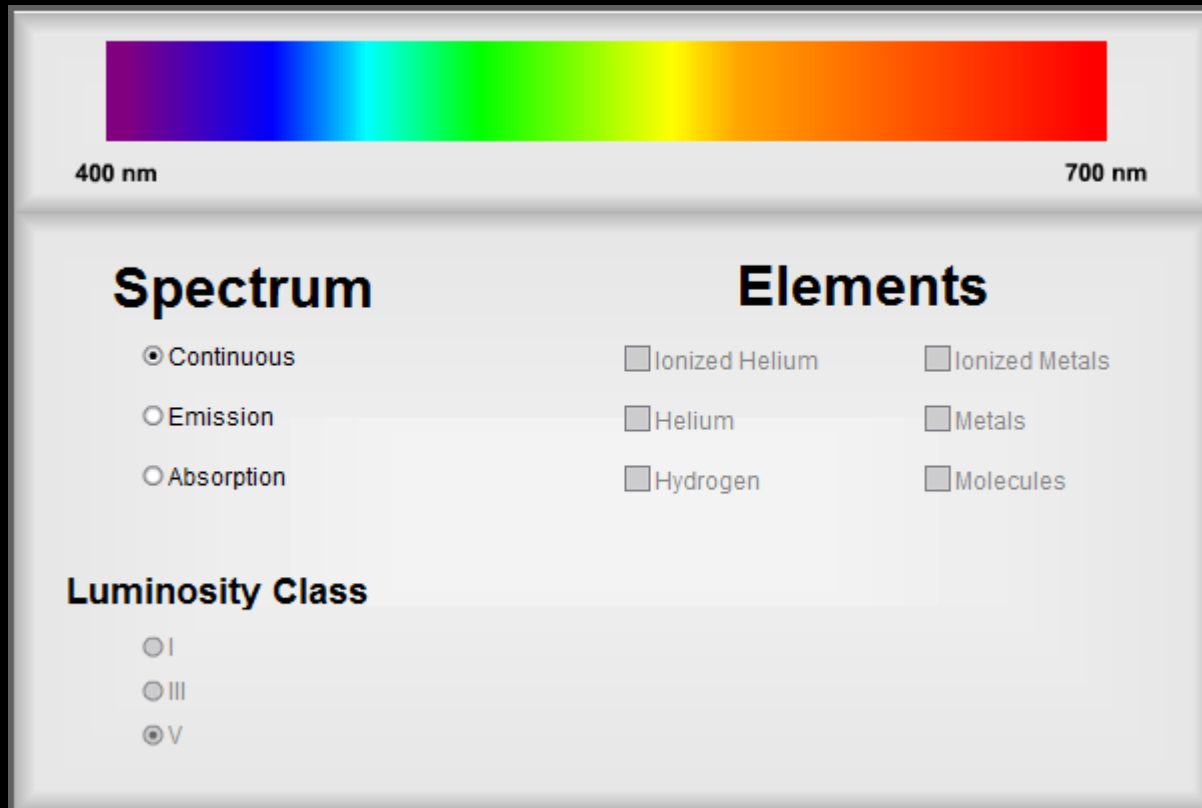
vertical scale

horizontal scale

- lock scale
- autoscale to all curves
- autoscale to selected curve

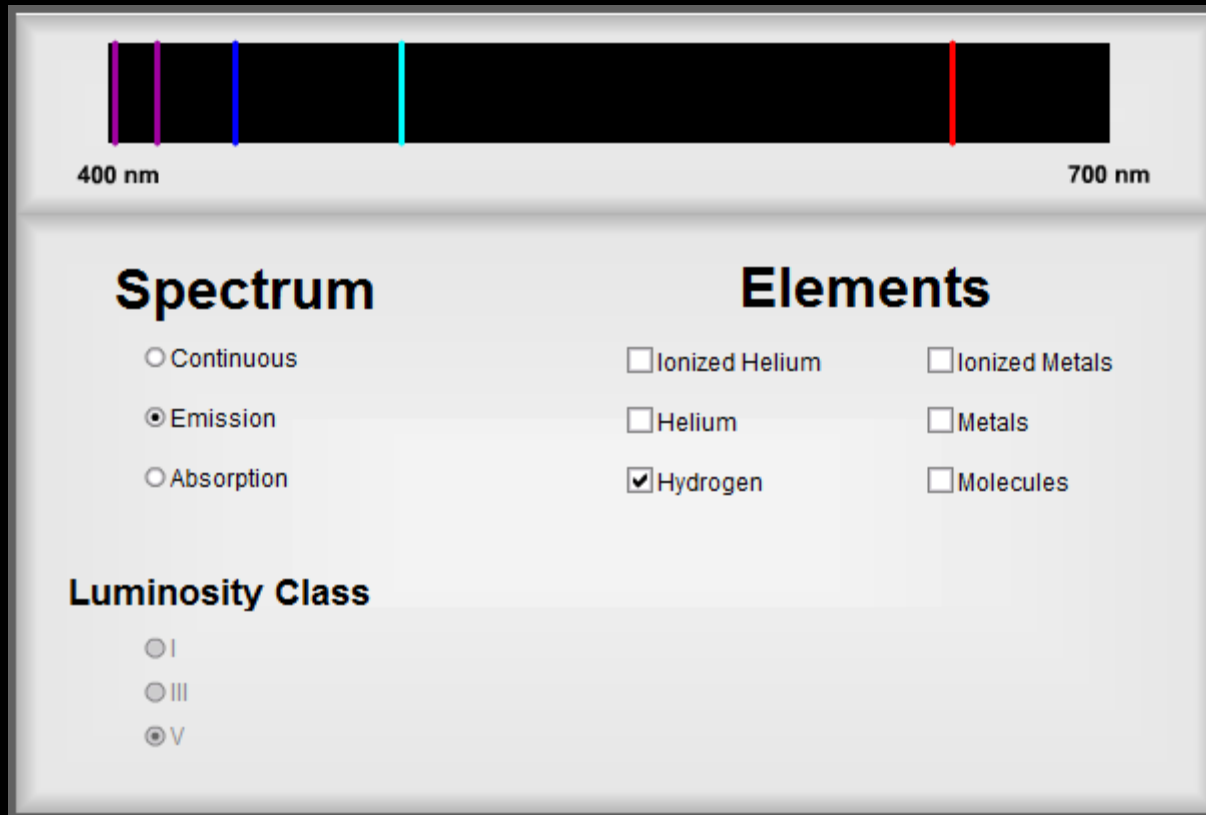
Spectrum of Light

Continuous Spectrum



Spectral Lines of Light

Hydrogen Emission Spectrum



Hydrogen (H)

Other Elements

Neutral Atom

Main Page

Finding List

Element Name

Atomic Number

Periodic Table

Atomic Data

Strong Lines

Persistent Lines

Energy Levels

Ref.

Switch to
Formatted Version

Strong Lines of Hydrogen (H)

Intensity		Wavelength (Å)	Spectrum	Ref.
Vacuum				
15		926.2256	H I	MK00a
20		930.7482	H I	MK00a
30		937.8034	H I	MK00a
50	P	949.7430	H I	MK00a
100	P	972.5367	H I	MK00a
300	P	1025.7222	H I	MK00a
1000	P	1215.66824	H I	MK00a
500	P	1215.67364	H I	MK00a
Air				
5		3835.384	H I	RCWM80
6		3889.049	H I	RCWM80
8		3970.072	H I	RCWM80
15		4101.74	H I	RCWM80
30	P	4340.462	H I	MK00a
30	P	4861.2786	H I	MK00a
10	P	4861.2870	H I	MK00a
60	P	4861.3615	H I	MK00a
90	P	6562.7110	H I	MK00a
30	P	6562.7248	H I	MK00a
180	P	6562.8518	H I	MK00a
5		9545.97	H I	RCWM80

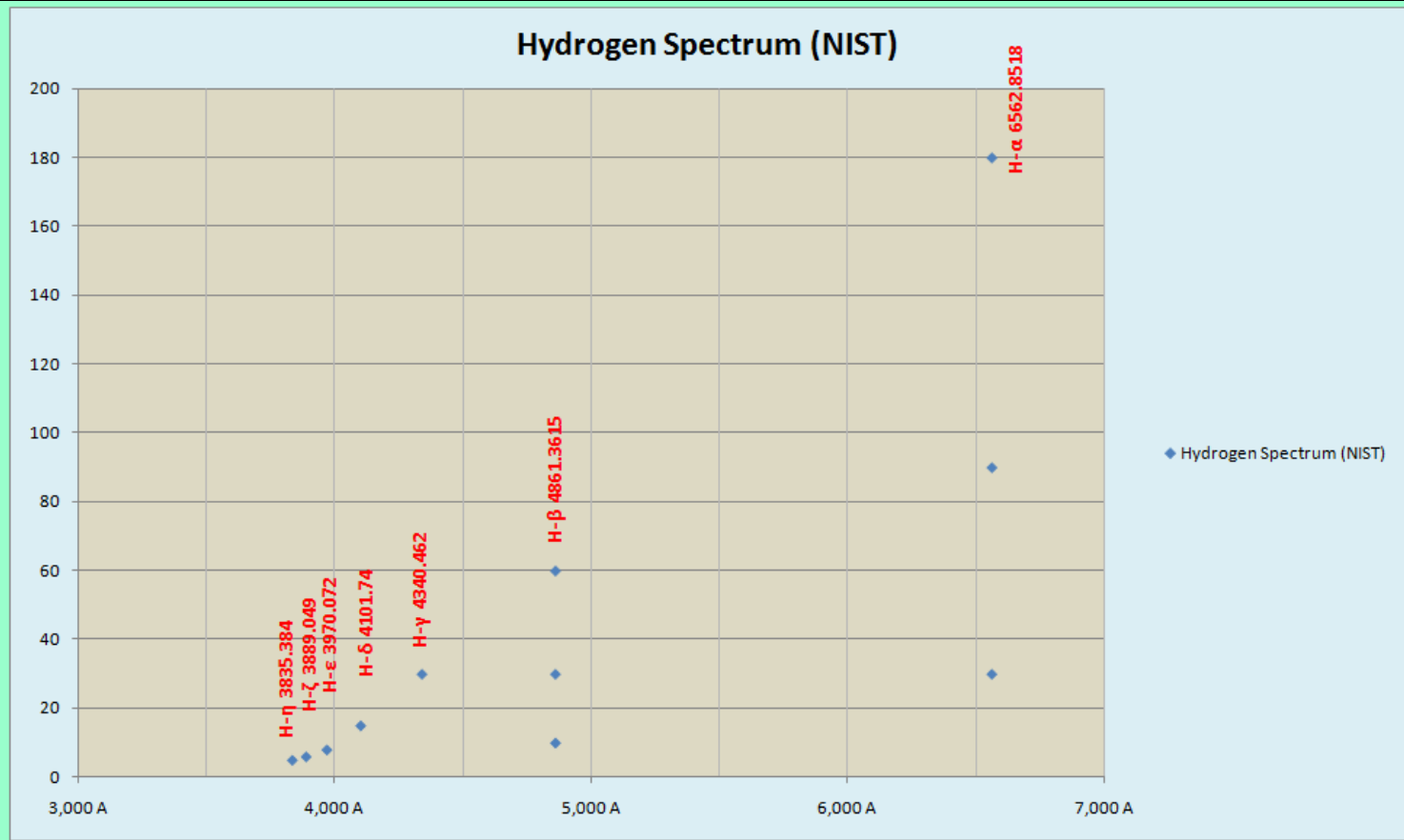
Strong Spectral Lines of Hydrogen

http://physics.nist.gov/PhysRefData/Handbook/Tables/hydrogentable2_a.htm

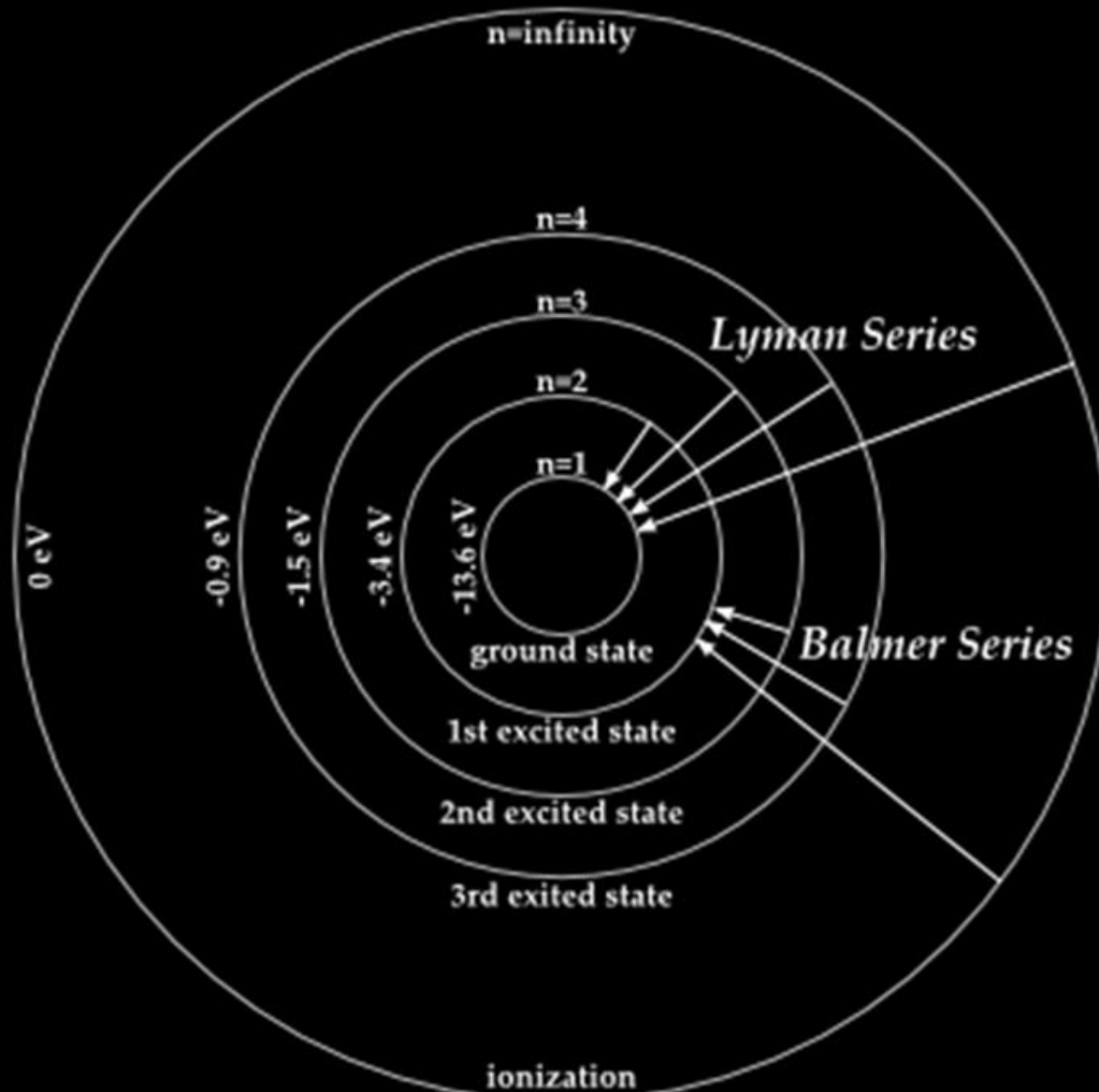
Strong Spectral Lines of Hydrogen

NIST

Angstroms	Intensity	Balmer Series	
3835.384	5	H-eta	η
3889.049	6	H-zeta	ζ
3970.072	8	H-epsilon	ϵ
4101.74	15	H-delta	δ
4340.462	30	H-gamma	γ
4861.2786	30		
4861.287	10		
4861.3615	60	H-beta	β
6562.711	90		
6562.7248	30		
6562.8518	180	H-alpha	α



Hydrogen Atom Energy Levels

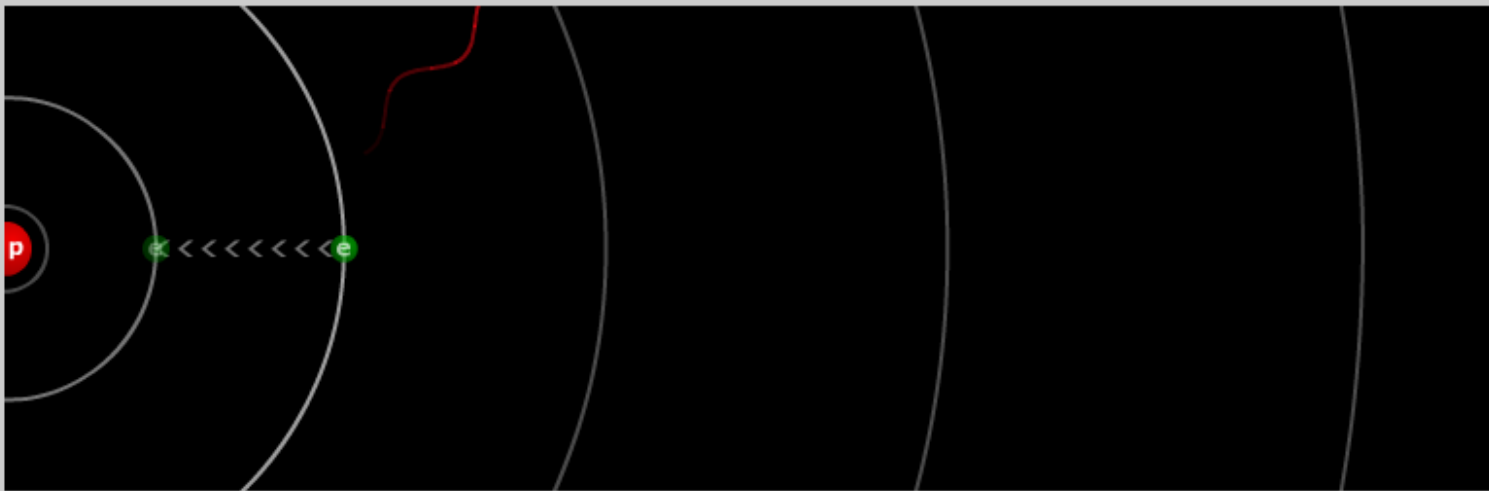


Hydrogen Atom Energy Levels

Hydrogen Atom Simulator

Credit <http://astro.unl.edu>

help about



Energy Level Diagram



level 2 ——— -3.4 eV

Photon Selection

frequency



wavelength



energy



infrared visible ultraviolet



P_{α} P_{γ} H_{β} H_{δ}

L_{α} L_{β} L_{γ} L_{ϵ}

P_{β} H_{α} H_{γ}

fire photon

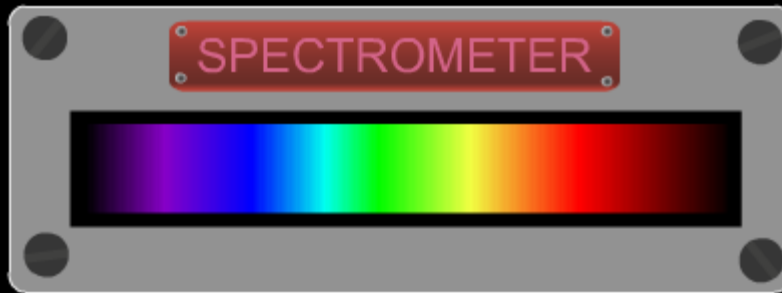
L_{δ}

Event Log

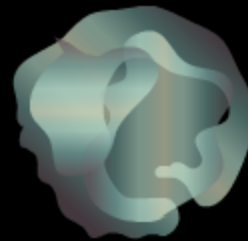
- deexcitation 1 ← 2 10.20 eV photon (L_{α}) emitted
- excitation 1 → 2 10.20 eV photon (L_{α}) absorbed
- excitation 2 → 3 1.89 eV photon (H_{α}) absorbed
- deexcitation 1 ← 3 12.09 eV photon (L_{β}) emitted
- excitation 1 → 2 10.20 eV photon (L_{α}) absorbed
- excitation 2 → 3 1.89 eV photon (H_{α}) absorbed
- deexcitation 2 ← 3 1.89 eV photon (H_{α}) emitted

clear log

Continuous Spectrum



Drag the telescope around to see how the three main types of spectra (continuous, absorption, and emission) are obtained from a cold, thin gas cloud and an incandescent lightbulb in space.

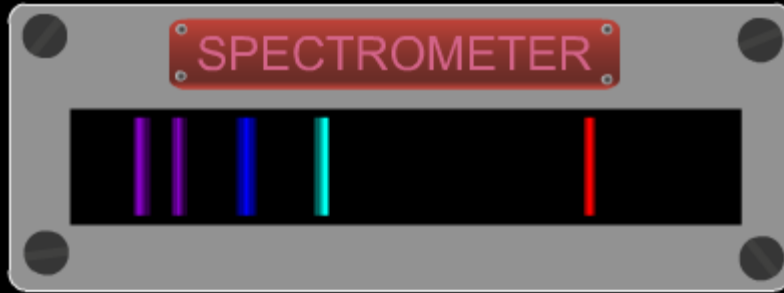


Star atmosphere,
Nebula, etc.

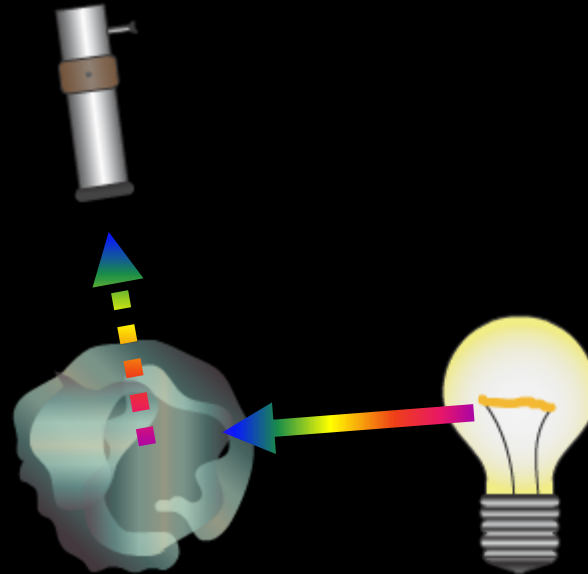


Star

Emission Spectrum



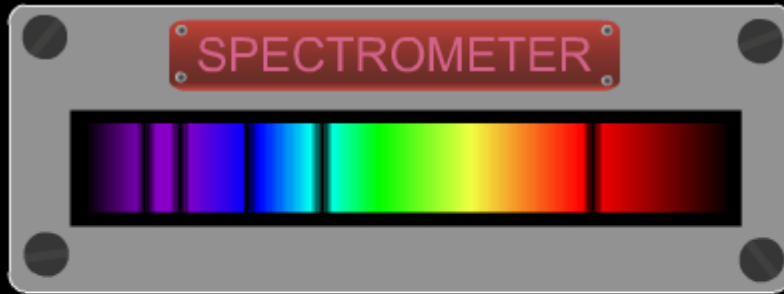
Drag the telescope around to see how the three main types of spectra (continuous, absorption, and emission) are obtained from a cold, thin gas cloud and an incandescent lightbulb in space.



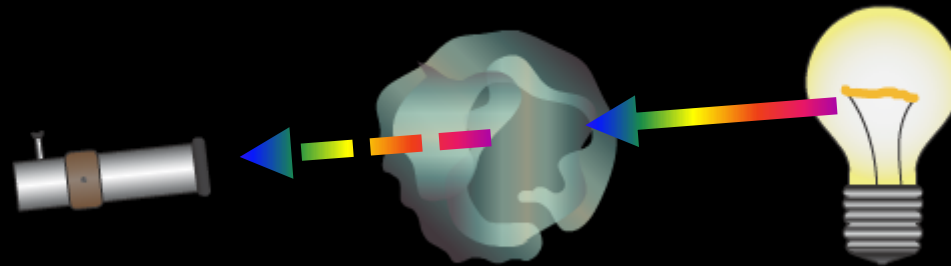
Star atmosphere,
Nebula, etc.

Star

Absorption Spectrum



Drag the telescope around to see how the three main types of spectra (continuous, absorption, and emission) are obtained from a cold, thin gas cloud and an incandescent lightbulb in space.



Star atmosphere,
Nebula, etc.

Star

Hydrogen Absorption Spectrum

Vega

H-epsilon



H-gamma



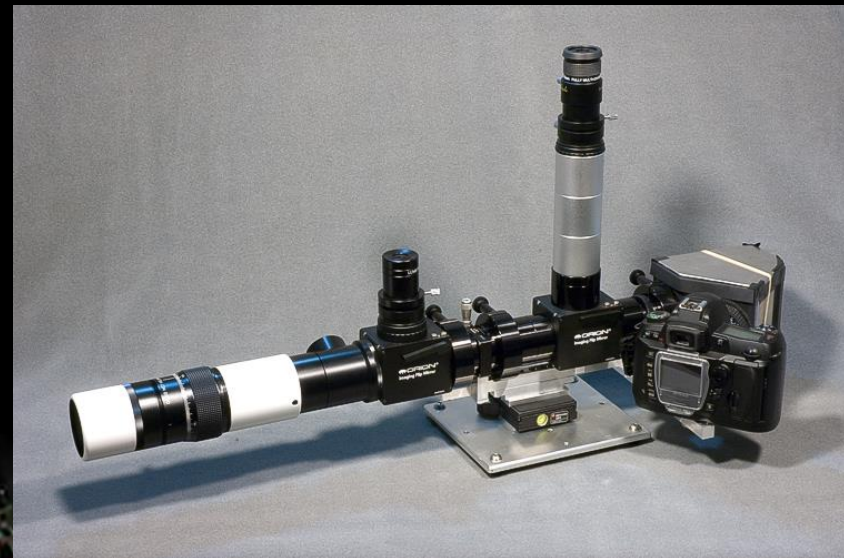
H-alpha



H-delta

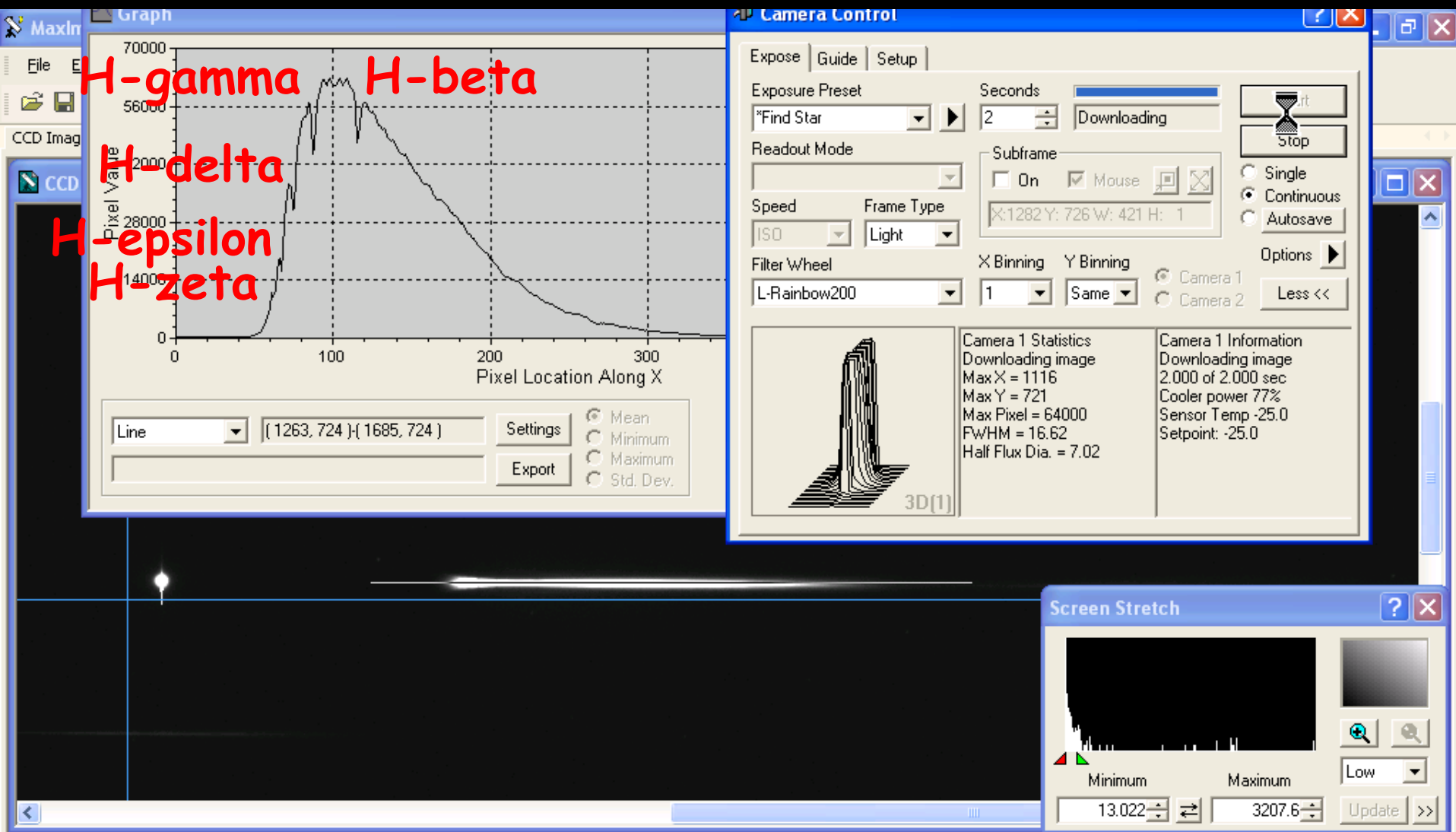


H-beta



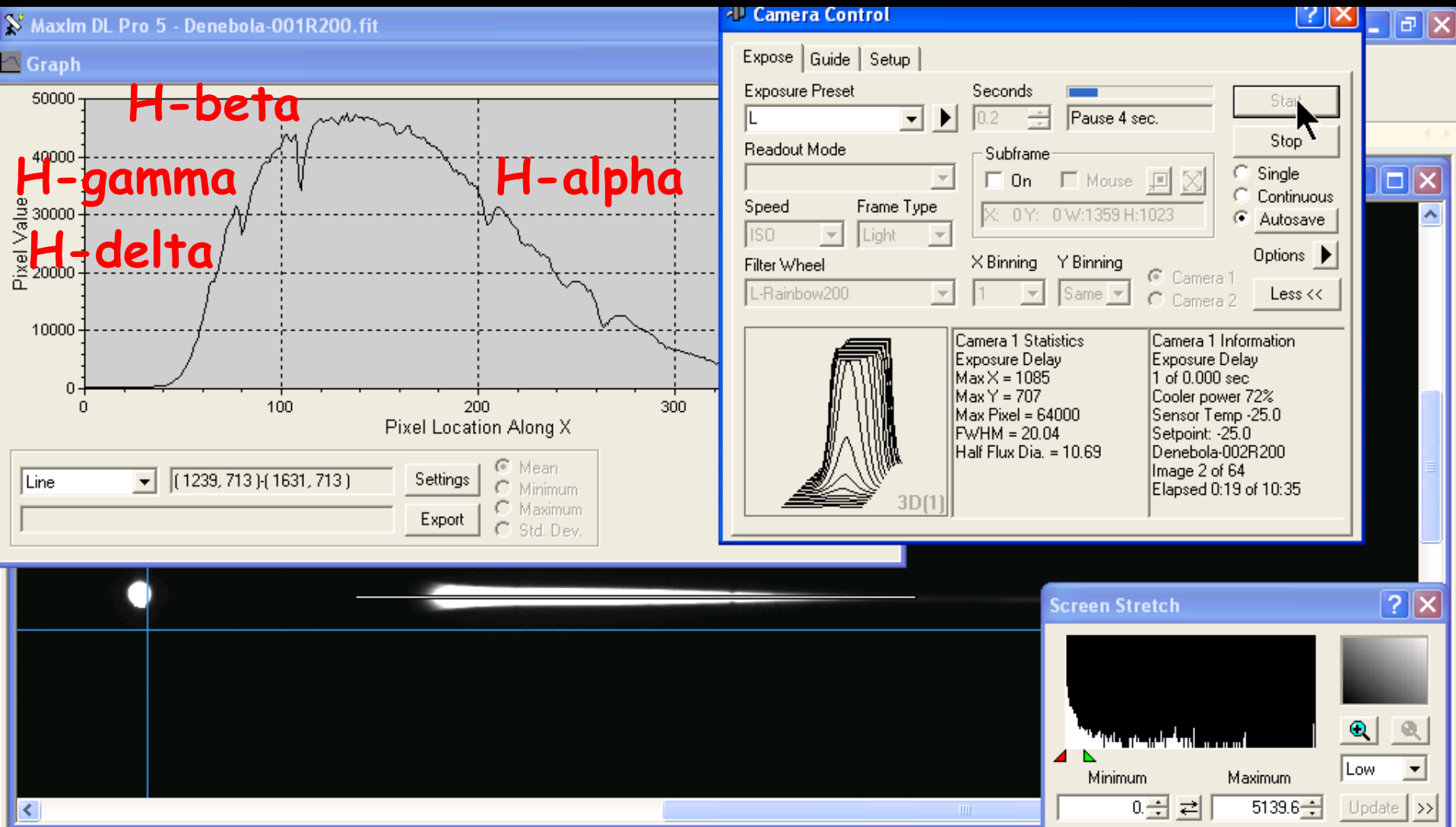
Hydrogen Absorption Spectrum

Denebola Spectrum



Hydrogen Absorption Spectrum

Denebola Spectrum

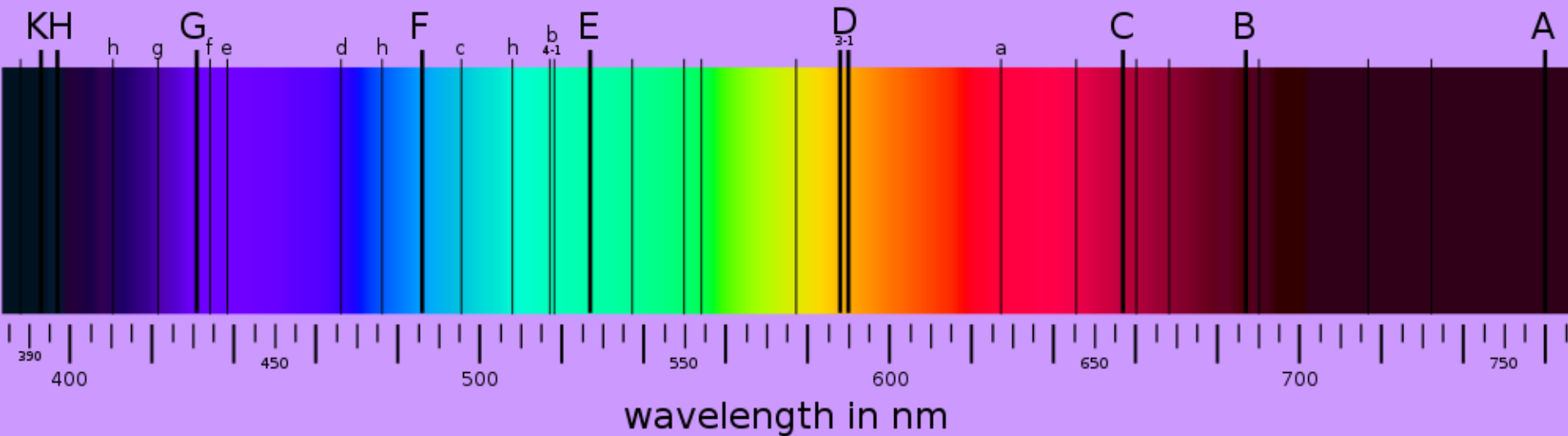


Fraunhofer Solar Spectrum Lines

Joseph von Fraunhofer (1787-1826)



Fraunhofer Solar Spectrum Lines



Name	wavelength [Angstrom]	origin
A	7594 [red]	terrestrial oxygen**
a	7165	terrestrial water vapour**
B	6867	terrestrial oxygen**
C	6563	H-alpha
D	5890, 5896	neutral sodium (Na)
E	5270	neutral iron (Fe)
b	5167, 5173, 5184	neutral magnesium (Mg)
F	4861	H-beta
d*	4384	neutral iron (Fe)
G	4300	CH band
g*	4227	neutral calcium (Ca)
h	4102	H-gamma
H	3968	ionized calcium (Ca)
K*	3934 [violet]	ionized calcium (Ca)

M. Gavin - 2

Note: Fraunhofer labeled lines from red to blue - the reverse of modern convention ordered by wavelength.

Fraunhofer Solar Lines

DVD Spectrograph



G: Ca, Fe, H_γ

F: H_β

b: Mg E: Fe

D: Na

Quantum Mechanics

Lines Energy Levels

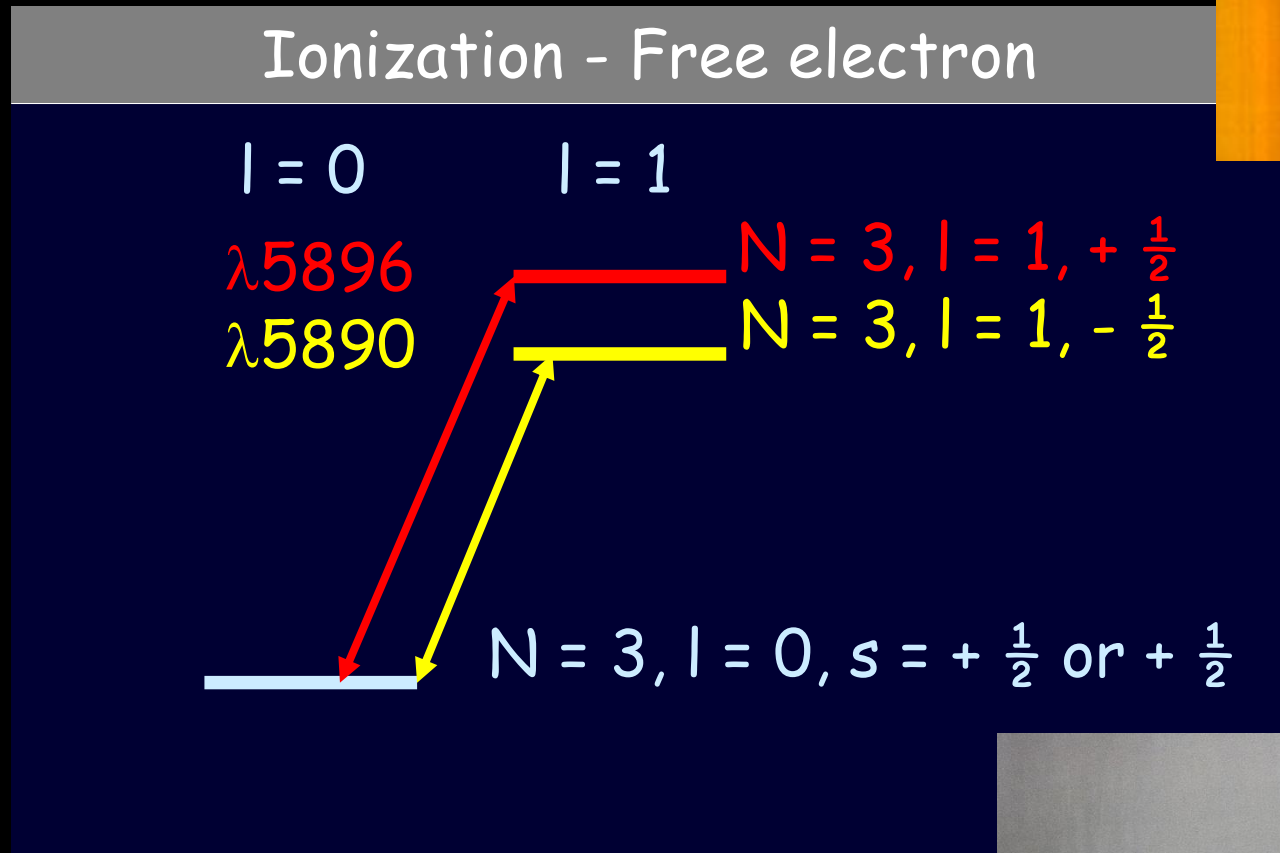
- Principal quantum number: n
- Angular momentum quantum number: l
 - (sharp 0, principal 1, diffuse 2 or fundamental 3)
- Magnetic quantum number: m
 - Same energy levels except in external magnetic fields.
- Spin quantum number: s
 - Spin up ($+\frac{1}{2}$) or spin down ($-\frac{1}{2}$)

Na Double Lines - Betelgeuse

Lines Energy Levels

0 eV

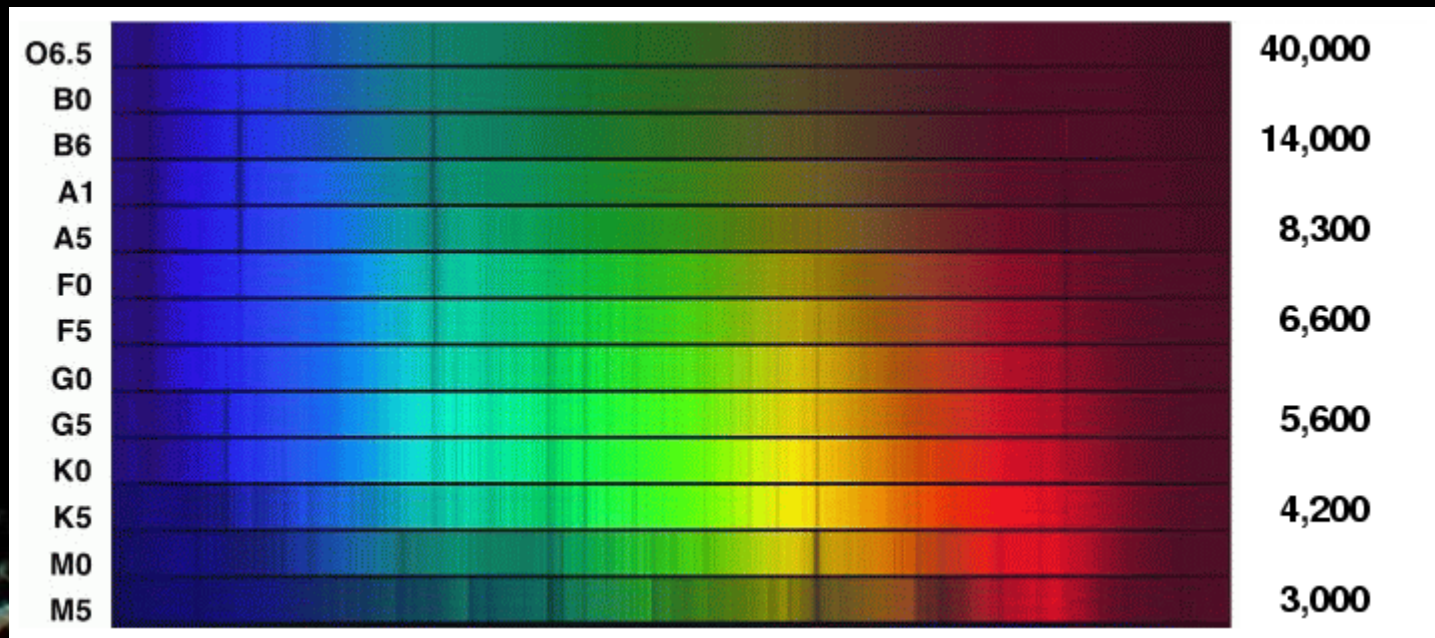
Energy eV



Early Astronomical Spectroscopy

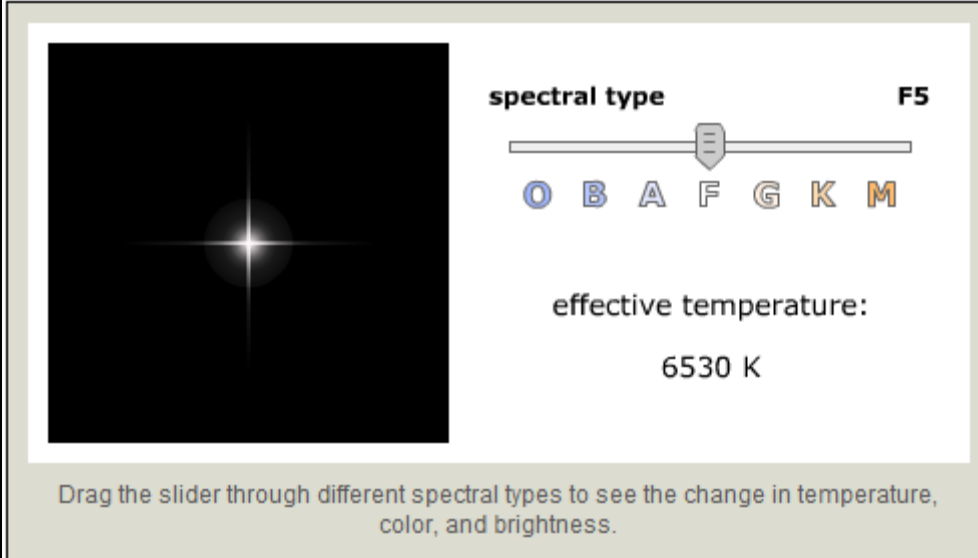
1890: Harvard College Observatory

- 1890: 1st Draper Memorial Catalogue 10,351 stars
- 1912: Last of the 4 Draper Memorial Catalogues
- 1922 IAU formal adoption of Draper system
- By temperature: OBAFGKM with decimal types



Star Classification

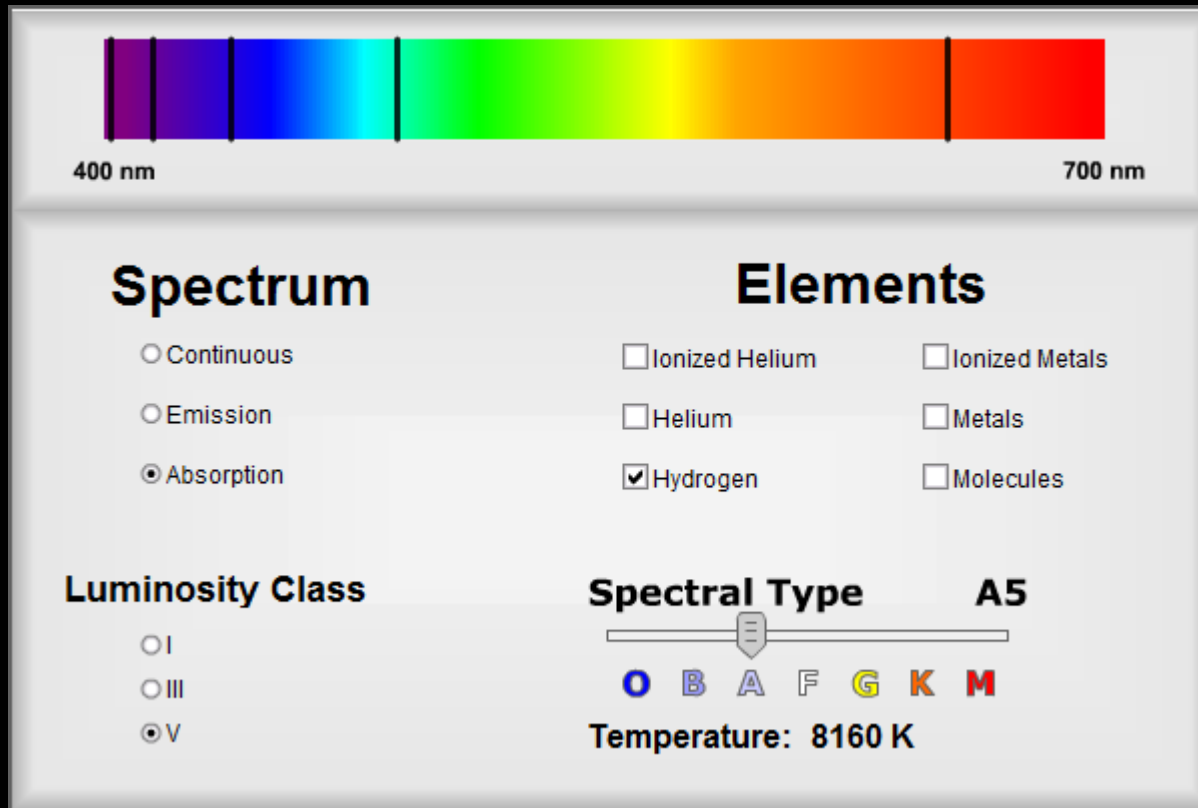
Spectral Type = Star Temperature



The image shows a simulation interface for star classification. On the left is a black square containing a bright star with a four-pointed diffraction pattern. To the right is a control panel. At the top, it says "spectral type" on the left and "F5" on the right. Below this is a horizontal slider with a grey arrow pointing to the right. Underneath the slider are the spectral type letters O, B, A, F, G, K, M in a row. Below the letters, it says "effective temperature:" followed by "6530 K". At the bottom of the panel, there is a light grey box with the text: "Drag the slider through different spectral types to see the change in temperature, color, and brightness."

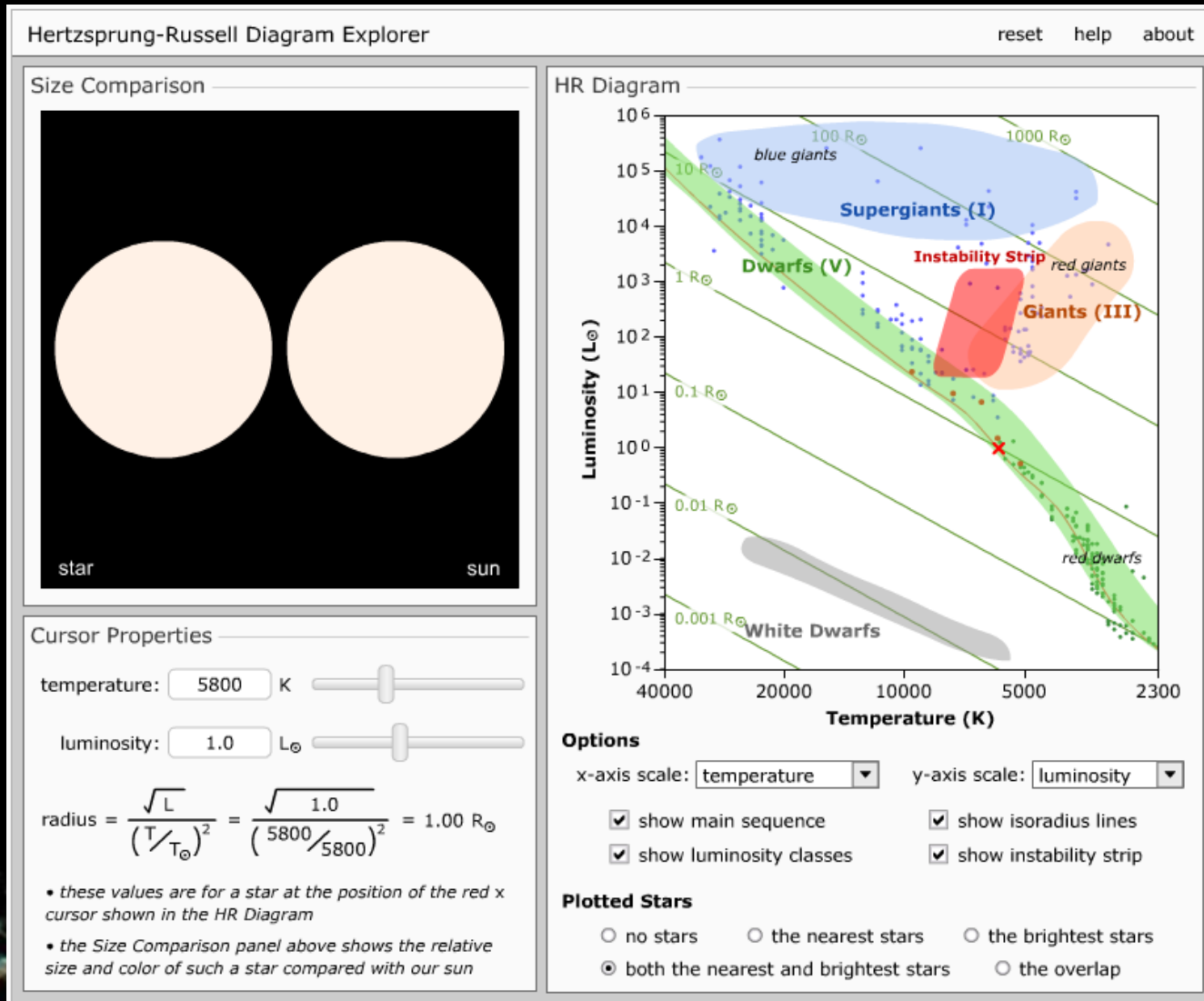
Spectral Lines of Light

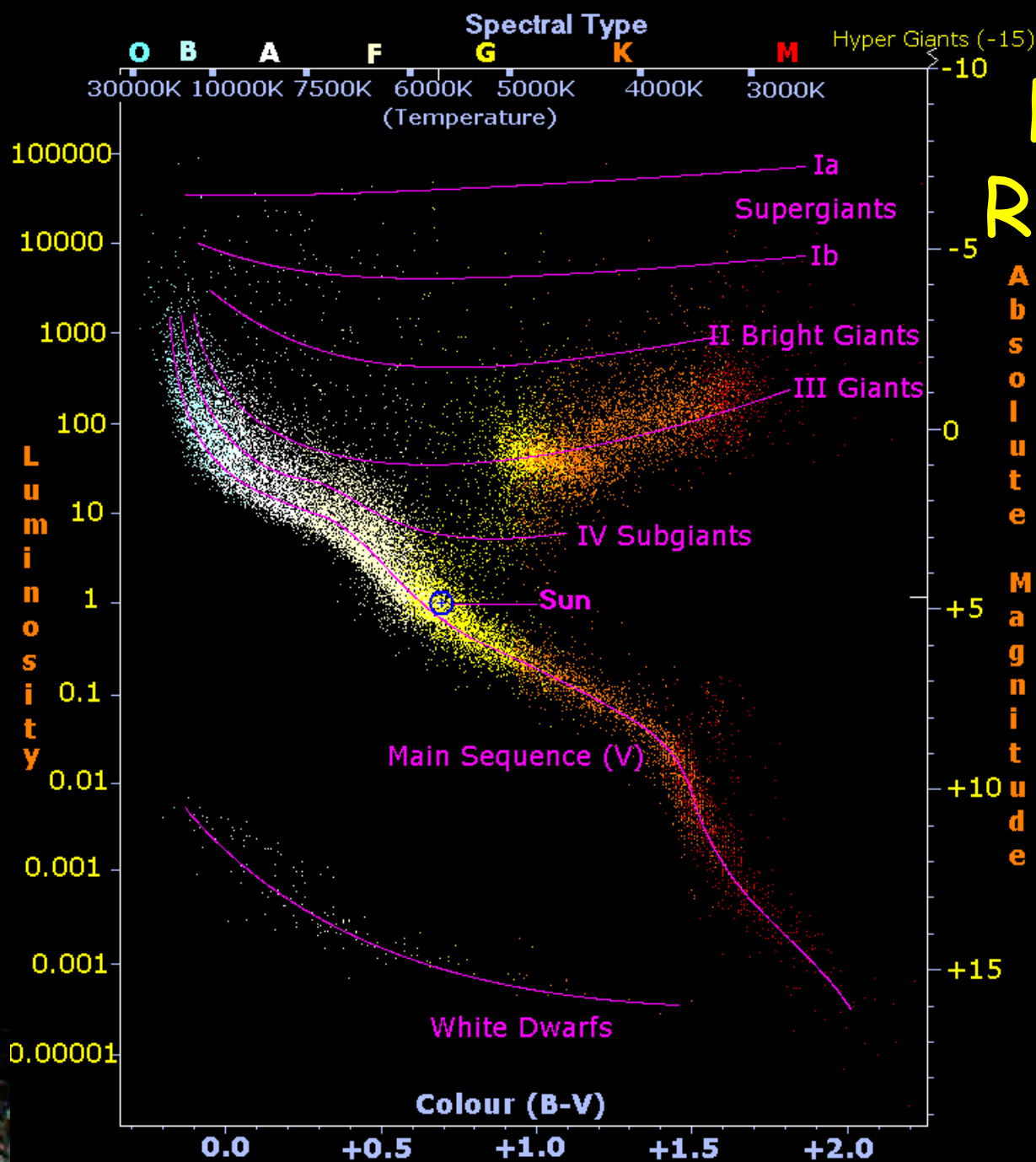
Hydrogen Absorption Spectrum



Hertzsprung-Russell Diagram

Luminosity vs. Temperature





Hertzsprung-Russell Diagram

22,000 stars from the Hipparcos Catalogue + 1,000 Low-lum.

Henry Draper Catalogues

Astronomical Spectroscopy

- 👁️ 1912-49: Harvard College Observatory
- 👁️ 225,300 stars Henry Draper (HD) Catalogue
- 👁️ 46,850 stars Henry Draper Extension (HDE)
- 👁️ 86,933 stars Henry Draper Extension Chart (HDEC)

Detailed Description of III/135A - Windows Internet Explorer

http://cdsarc.u-strasbg.fr/viz-bin/Cat?cat=III%2F135A&target=brief

CDs Centre de Données Astronomiques de Strasbourg

Simbad VizieR Aladin Catalogs Dictionary

Detailed Description of III/135A

[Brief summary](#) [ReadMe](#)

III/135A	Henry Draper Catalogue and Extension (Cannon+ 1918-1924; ADC 1989) HD
	The Henry Draper Catalogue (edition 1989)
Author(s)	Cannon A.J., Pickering E.C.: 1918-1925
Object type	stars
Keywords	Spectral types; Surveys
Category	Observational catalogue [OC]
Note	Supersedes III/99/
Statistics	272150 stars (size: 12Mb)
Popularity	<input type="checkbox"/>
Note	12Mb
Added to VizieR	25-Apr-1994

http://astrobib.u-strasbg.fr:2008/cgi-bin/cdsbib

Detailed Description of III/182 - Windows Internet Explorer

http://cdsarc.u-strasbg.fr/viz-bin/Cat?cat=III%2F182&target=brief

CDs Centre de Données Astronomiques de Strasbourg

Simbad VizieR Aladin Catalogs Dictionary Biblio Tutorials Developers

Detailed Description of III/182

[Brief summary](#) [ReadMe](#) [Browse](#) [FTP](#) [tar](#)

III/182	HDE Charts: positions, proper motions (Nesterov+ 1995) HD
	The HDE Charts: accurate positions, proper motions, magnitudes and spectral types of 86933 stars
Author(s)	CANNON A.J., MAYALL M.W.
Bibcode	1995A&AS..110..367N 1949AnHar.112....1C
Object type	stars
Category	Critical compilation catalog [CCC]
Note	See also III/138/
Statistics	86933 stars (size: 5.3Mb)
Popularity	<input type="checkbox"/>
Note	5.3Mb
Added to VizieR	18-May-1995

Internet | Protected Mode: On

Microsoft WorldWide Telescope

Vega, Lyra

The screenshot shows the Microsoft WorldWide Telescope interface. At the top, there are navigation tabs: Explore, Guided Tours, Search, Community, Telescope, View, and Settings. The Search tab is active, and the search bar contains "HD40183". Below the search bar, there are fields for "J2000", "RA", and "Dec", all set to "0". A "Go" button and a "Search View" button are also present. The main view shows a star field with a constellation grid. A "Finder Scope" window is open, displaying a magnified view of a star. The Finder Scope window contains the following information:

Finder Scope

Classification: Star in Lyra

Names: Vega; HIP91262

RA :	18h36m56s	Magnitude:	0.03
Dec :	38 : 47 : 01	Distance:	25 ly
Alt :	79 : 21 : 19	Rise:	01:49
Az :	143 : 21 : 10	Transit:	12:04
		Set:	22:23

Image Credits: Copyright DSS Consortium

At the bottom of the interface, there is a "Look At" dropdown menu set to "Sky", an "Imagery" section with a "Digitized Sky" button and a URL <http://www-gsss.stsci.edu/Acknowledgeme...>, and a "Context Search Filter" dropdown set to "All". There are also several thumbnail images of celestial objects, including "Ring Beholds a D...", "The Ring Nebula...", "A Bird's Eye View...", "Ring Nebula", "M56", and "M57". A "Lyra" constellation window is open in the bottom right corner, showing a magnified view of the constellation and its coordinates: RA : 18h35m00s, Dec : +33:24:54.

SIMBAD

Vega AOV

Web Window - Maximize window for full browser

SIMBAD query result

28-Dec-2009: Hierarchical links are now available for several objects. See details [here](#).

other query modes : [Identifier query](#) [Coordinate query](#) [Criteria query](#) [Bibliography query](#) [Basic query](#) [Script submission](#) [Output options](#) [Help](#)

Object query : Vega C.D.S. - SIMBAD4 rel 1.136 - 2009.12.31CET03:26:11

[Available data](#) [Basic data](#) [Identifiers](#) [Plot & images](#) [Bibliography](#) [Measurements](#) [External archives](#) [Notes](#)

Basic data :

V* alf Lyr -- Variable Star with radius arcmin

Other object types: *

(*, AG, ASCC, BD, CSI, FK5, GC, GCRV, GEN#, GJ, HD, HGAM, HIC, HIP, HR, JP11, N30, 8pc, PLX, PMC, PPM, ROT, SAO, SKY; [HFE83]) , IR (IRAS, IRC, 2MASS, RAFGL) , ** (ADS, CCDM, IDS) , PM* (LSPM, LTT, NLTT) , V* (V*, CSV, NSV) , (1E)

ICRS coord. (ep=2000): 18 36 56.3364 +38 47 01.291 (~) [5.65 4.88 144] A [1997A&A...323L..49P](#)

FK5 coord. (ep=2000 eq=2000): 18 36 56.336 +38 47 01.29 (~) [5.65 4.88 144] A [1997A&A...323L..49P](#)

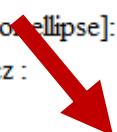
067.4482 +19.2373 (~) [5.65 4.88 144] A [1997A&A...323L..49P](#)

Proper motions *mas/yr* [error ellipse]: 201.03 287.47 [0.63 0.54 144] A [1997A&A...323L..49P](#)

Radial velocity / Redshift / cz: V(km/s) -13.9 [0.9] / z(~) -0.000046 [0.000003] / cz -13.90 [0.90] (~) A [1979IAUS...30...57I](#)

Parallaxes *mas*: 128.93 [0.55] A [1997A&A...323L..49P](#)

Spectral type: A0V C ~



Spectral Type

Vega **A0V**

Spectral Type	Surface Temperature	Distinguishing Features
O	> 25,000K	H; HeI; HeII
B	10,000-25,000K	H; HeI; HeII absent
A	7,500-10,000K	H; CaII; HeI and HeII absent
F	6,000-7,500K	H; metals (CaII, Fe, etc)
G	5,000-6,000K	H; metals; some molecular species
K	3,500-5,000K	metals; some molecular species
M	< 3,500K	metals; molecular species (TiO!)
C	< 3,500K	metals; molecular species (C2!)

Luminosity Class

Vega A0V

Luminosity Class	Description	Comments
0	Hypergiants	extreme
Ia	Supergiants!	large and luminous
Ib	Supergiants!	less luminous than Ia
II	Bright Giants	
III	Giants	
IV	Sub-Giants	
V	Dwarfs	Main Sequence
sd	Sub-Dwarfs	
D	White Dwarfs	



SIMBAD

Vega, HD172167

Web Window - Maximize window for full browser

from: to:

Measurements (20 types) :

CEL : 1 Fe_H : 21 GEN : 1 GJ : 1 Hbet1 : 3 IRAS : 1 IRC : 1 ISO : 99 IUE : 65 JP11 : 5 MK : 33 oRV : 17

PLX : 4 PM : 3 pos : 2 ROT : 6 SAO : 1 TD1 : 1 UBV : 13 uvby1 : 7


External archives :

Archive data at [HEASARC - High-Energy Astrophysics Science Archive Research Center](#)

Catalogue information from [VizieR](#)

V* alf Lyr	AG+38 1711	BD+38 3238	CCDM J18369+3847A	EUVE J1836+38.7
FK5 699	GJ 721	HD 172167	HIC 91262	HIP 91262
HR 7001	IRAS 18352+3844	IRC +40322	LSPM J1836+3847	2MASS J18365633+3847012
NLTT 46746	NSV 11128	PPM 81558	RAFGL 2208	SAO 67174
USNO-B1.0 1287-00305764				





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VizieR Detail Page

Vega, HD172167

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VizieR Detailed Page

[Henry Draper Catalogue and Extension \(Cannon+ 1918-1924; ADC 1989\)](#) [ReadMe](#) HD==172167

The catalogue (272150 rows)

Column	Value	Explain (UCD)
<u>RA</u> J2000	18 37.0 "h:m:s"	Right ascension (FK5) Equinox=J2000.0 Epoch=J1900. (computed by VizieR, not part of the original data) (pos.eq.ra;meta.main) (POS EQ RA MAIN)
<u>DE</u> J2000	+38 46 "d:m:s"	Declination (FK5) Equinox=J2000.0 Epoch=J1900. (computed by VizieR, not part of the original data) (pos.eq.dec;meta.main) (POS EQ DEC MAIN)
<u>RA</u> B1950	18 35.3 "h:m:s"	Right ascension (FK4) Equinox=B1950.0 Epoch=J1900. (computed by VizieR, not part of the original data) (pos.eq.ra;meta.main) (POS EQ RA MAIN)
<u>DE</u> B1950	+38 44 "d:m:s"	Declination (FK4) Equinox=B1950.0 Epoch=J1900. (computed by VizieR, not part of the original data) (pos.eq.dec;meta.main) (POS EQ DEC MAIN)
<u>Gl</u> on	067.43 deg	Galactic longitude Epoch=J1900. (computed by VizieR, not part of the original data) (pos.galactic.lon) (POS GAL LON)
<u>Gl</u> at	+19.23 deg	Galactic latitude Epoch=J1900. (computed by VizieR, not part of the original data) (pos.galactic.lat) (POS GAL LAT)
HD	172167	[1/272150] Henry Draper Catalog (HD) number (meta.id;meta.main) (ID MAIN)
DM BD	+38 3238	Durchmusterung identification (Note 1) (meta.id) (ID ALTERNATIVE)
RAB1900	18 33.6 "h:m:s"	Hours RA, equinox B1900, epoch 1900.0 (pos.eq.ra;meta.main) (POS EQ RA MAIN)
DEB1900	+38 41 "d:m:s"	Degrees Dec, equinox B1900, epoch 1900.0 (pos.eq.dec;meta.main) (POS EQ DEC MAIN)
q_Ptm	0	[0/1] Code for Ptm: 0 = measured, 1 = value inferred from Ptg and spectral type (meta.code.qual) (CODE QUALITY)
Ptm	0.14 mag	Photovisual magnitude (Note 2) (phot.mag;em.opt.V) (PHOT PHG V)

VizieR Detail Page

Vega, HD172167

Web Window - Maximize window for full browser

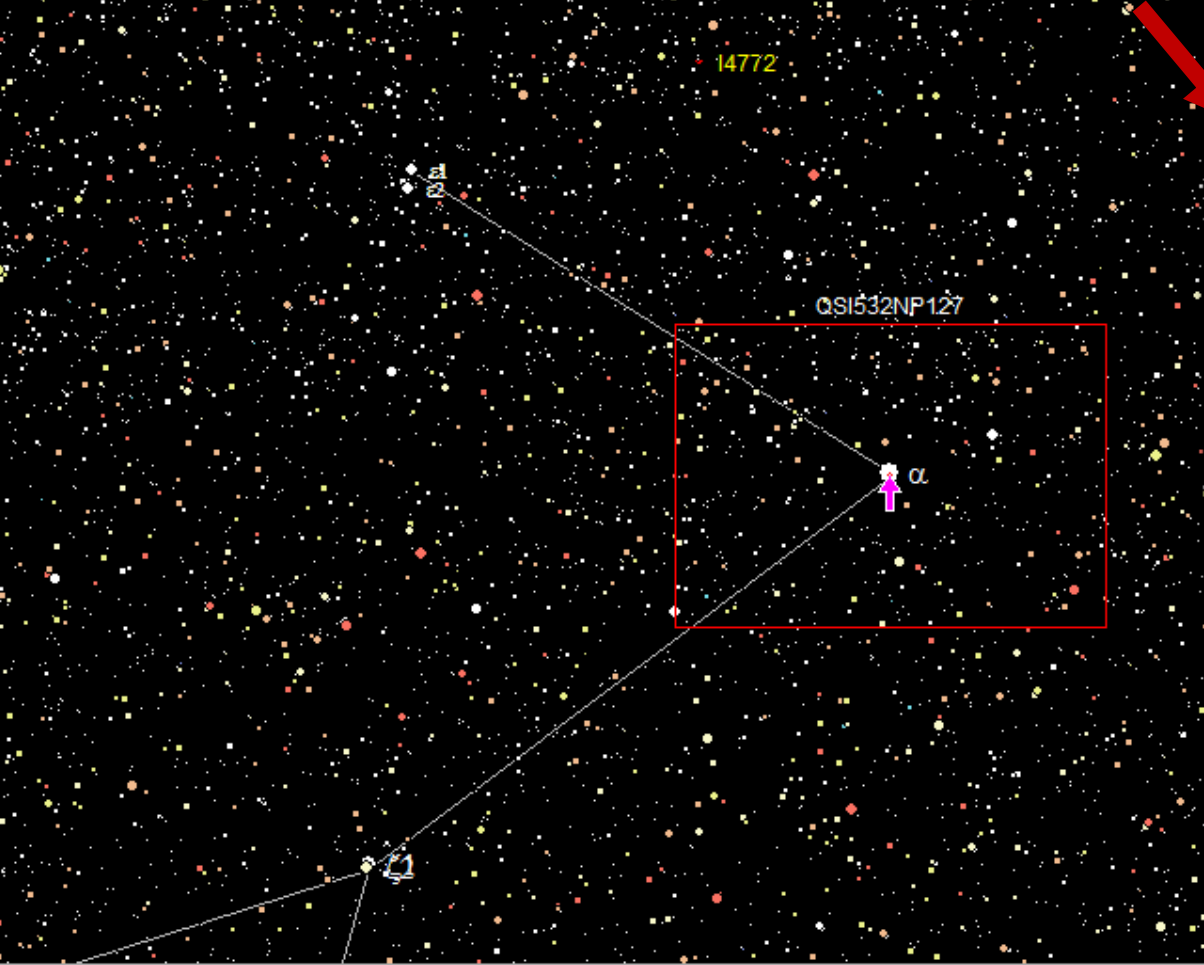
_DEB1950	+38 44	"dms"	Declination (FK4) Equinox=B1950.0 Epoch=J1900. (computed by VizieR, not part of the original data) (pos.eq.dec;meta.main) (POS EQ DEC MAIN)
_Glon	067.43	deg	Galactic longitude Epoch=J1900. (computed by VizieR, not part of the original data) (pos.galactic.lon) (POS GAL LON)
_Glat	+19.23	deg	Galactic latitude Epoch=J1900. (computed by VizieR, not part of the original data) (pos.galactic.lat) (POS GAL LAT)
<hr/>			
HD	172167		[1/272150] Henry Draper Catalog (HD) number (meta.id;meta.main) (ID MAIN)
DM	BD+38 3238		Durchmusterung identification (Note 1) (meta.id) (ID ALTERNATIVE)
RAB1900	18 33.6	"hms"	Hours RA, equinox B1900, epoch 1900.0 (pos.eq.ra;meta.main) (POS EQ RA MAIN)
DEB1900	+38 41	"dms"	Degrees Dec, equinox B1900, epoch 1900.0 (pos.eq.dec;meta.main) (POS EQ DEC MAIN)
q_Ptm	0		[0/1] Code for Ptm: 0 = measured, 1 = value inferred from Ptg and spectral type (meta.code.qual) (CODE QUALITY)
Ptm	0.14	mag	Photovisual magnitude (Note 2) (phot.mag;em.opt.V) (PHOT PHG V)
n_Ptm			[C] 'C' if Ptm is combined value with Ptg (meta.note) (NOTE)
q_Ptg	1		[0/1] Code for Ptg: 0 = measured, 1 = value inferred from Ptm and spectral type (meta.code.qual) (CODE QUALITY)
Ptg	0.14	mag	Photographic magnitude (Note 2) (phot.mag;em.opt) (PHOT PHG MAG)
n_Ptg			[C] 'C' if Ptg is combined value for this entry and the following or preceding entry (meta.note) (NOTE)
SpT	A0		Spectral type (<i>spectral types P are generally nebulae</i>) (src.spType) (SPECT TYPE GENERAL)
Int			[0-9B] Photographic intensity of spectrum (Note 3) (phot.count;em.opt) (PHOT INTENSITY ESTIMATED)
Rem	R		[DEGMR*] Remarks, see note (Note 4) (meta.note) (REMARKS)
<hr/>			
Simbad	Simbad		ask the <i>Simbad</i> data-base about this object (DATA LINK)
Tycho	Tycho		Cross-identification with Tycho-2 (Cat. IV/25) (meta.ref.url) (DATA LINK)

Vega HD172167

Sky Charts V2.76c

My home 2010-3-21 9h05m C: 18h37m +38°47' L:+05°38' O:0° ARC EQ Magn: 13.8 Cat: QSO BSC SKY GSC TY2 NGC

File Edit View Move Search Preferences Lines Images Telescope Help



14772

QSI532NP127

α

Identification

Star

HR 7001 HD172167
Flamsteed Number: 3
Bayer Letter: Alpha
Constellation: Lyra
Visual Magnitude: 0.03
Color Index: 0.00
Spectral Class: A0Va
Annual Proper Motion: 0.202 0.286
VEGA; Wega; Fidis; Harp Star

J2000 RA: 18h36m56.30s DE:+38°47'01.0"
Date RA: 18h37m16.89s DE:+38°47'34.0"

My home 2010-3-21 9h05m (TU + -7h00m)
Sideral Time : 19h52m
Hour Angle : 1h14m
Azimuth :+249°59'
Altitude :+74°40'

Rise : 22h04m Azimuth:+24°57'

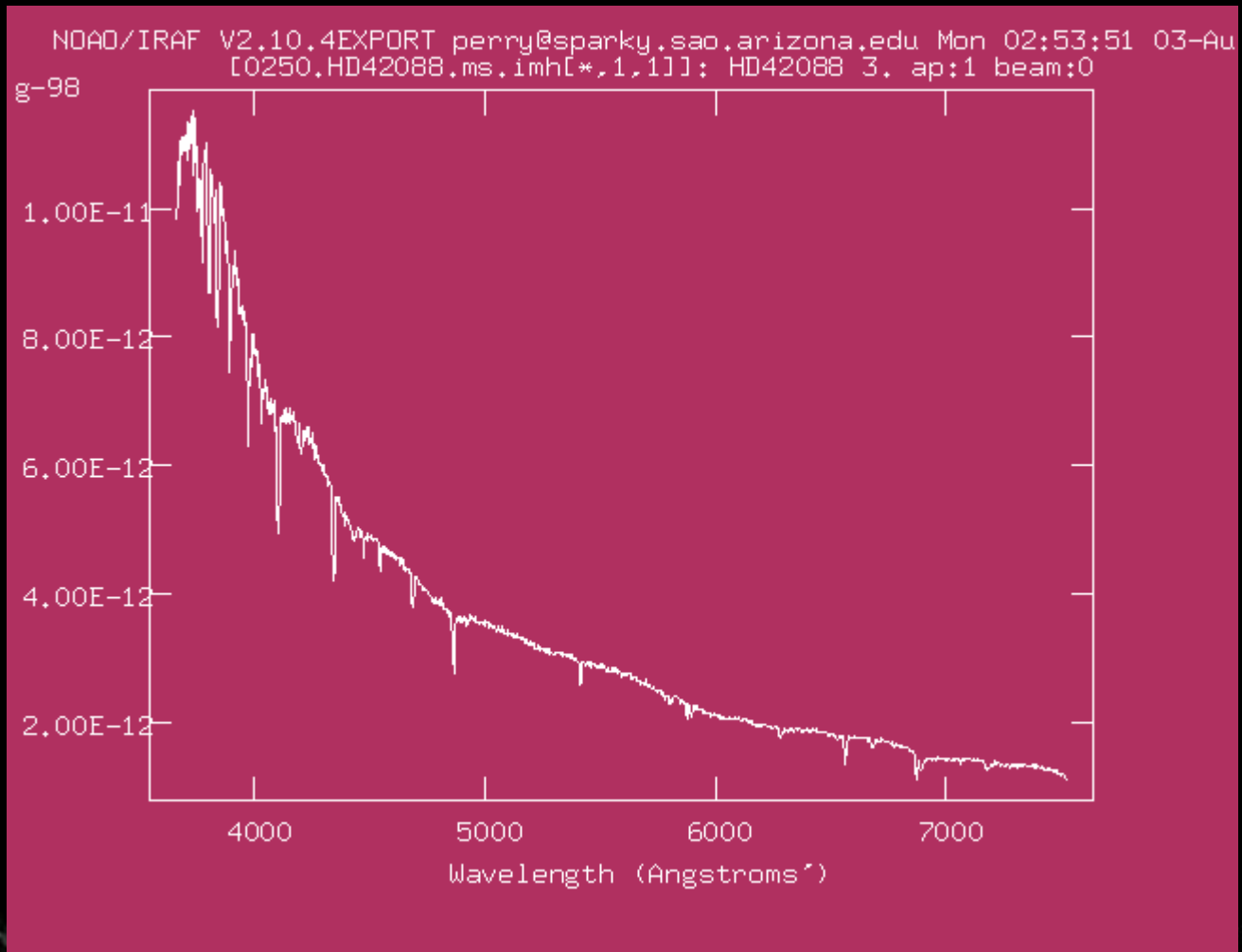
Close Center object Neighbor Clipboard

||Ra: 18h33m27.6s +40°11'11" | 18h36m56.30s +38°47'01.0" * HR 7001 HD172167 Fl: 3 Ba:Alp const:Lyr mV: 0.03 b-v: 0.00 sp: A0Va pm: 0.202 0.286 ;VEGA; Wega; Fidis; Harp Star

E
S
W
Scope
Show
Track
Sync
Goto

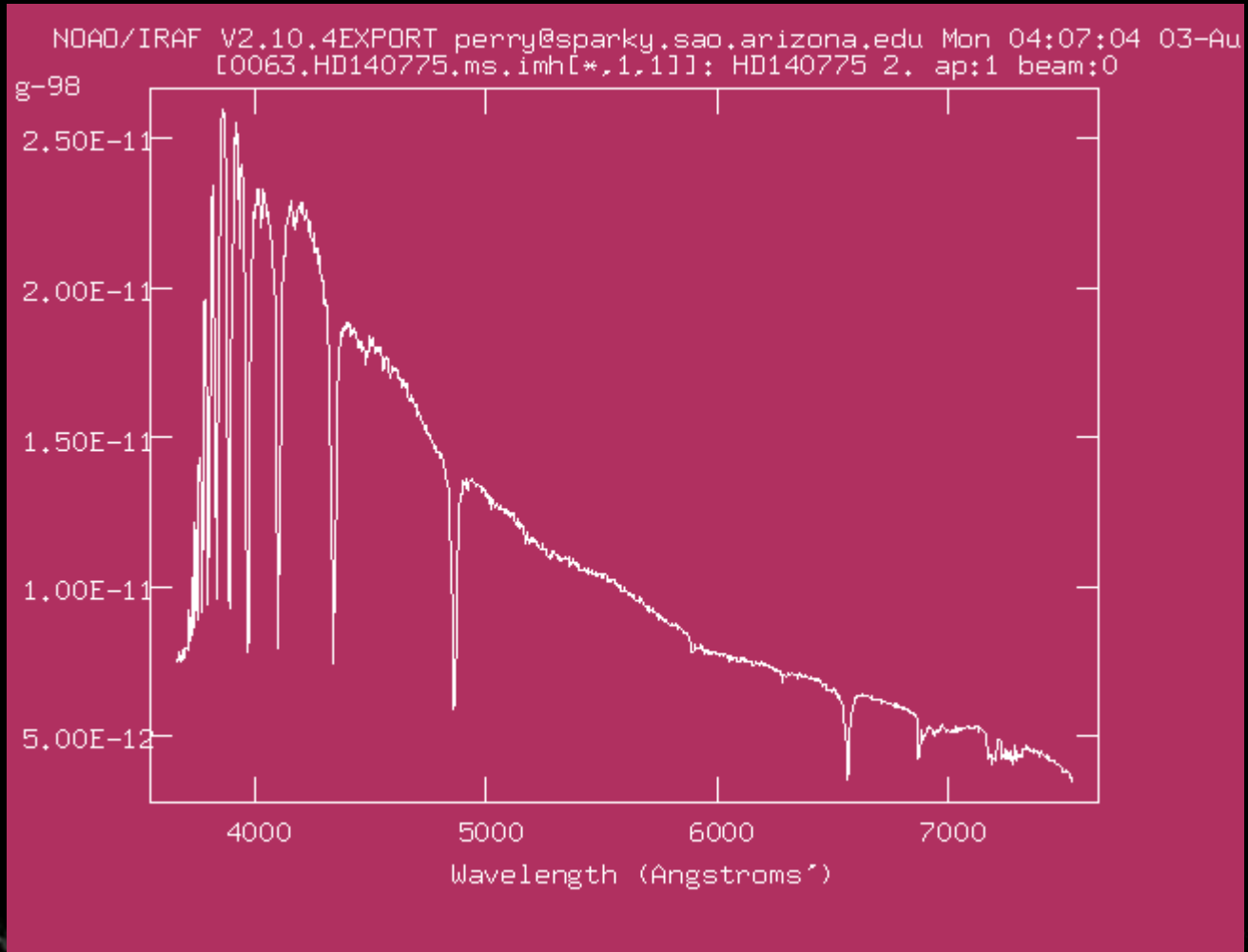
HD42088

O6V



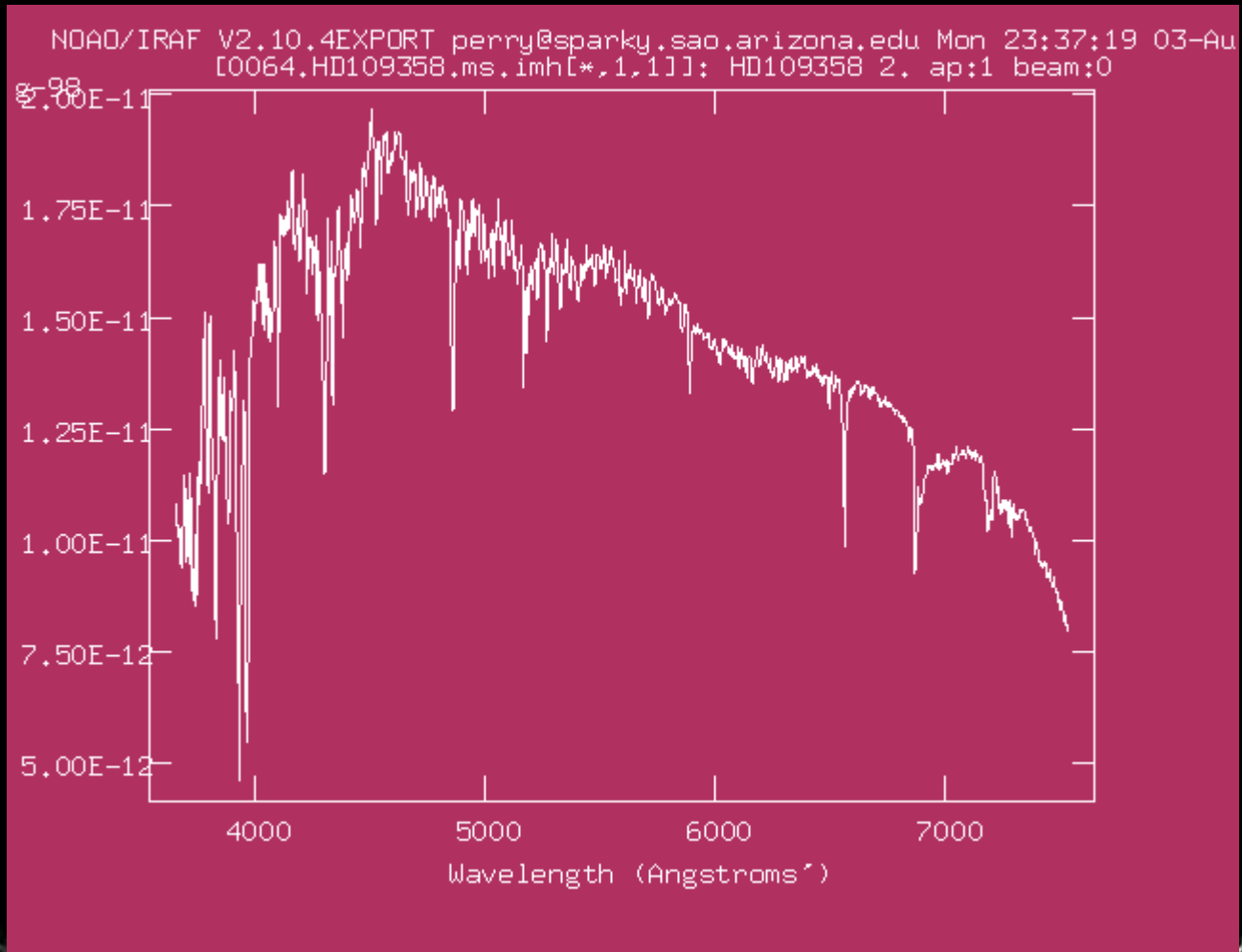
HD140775

AOV



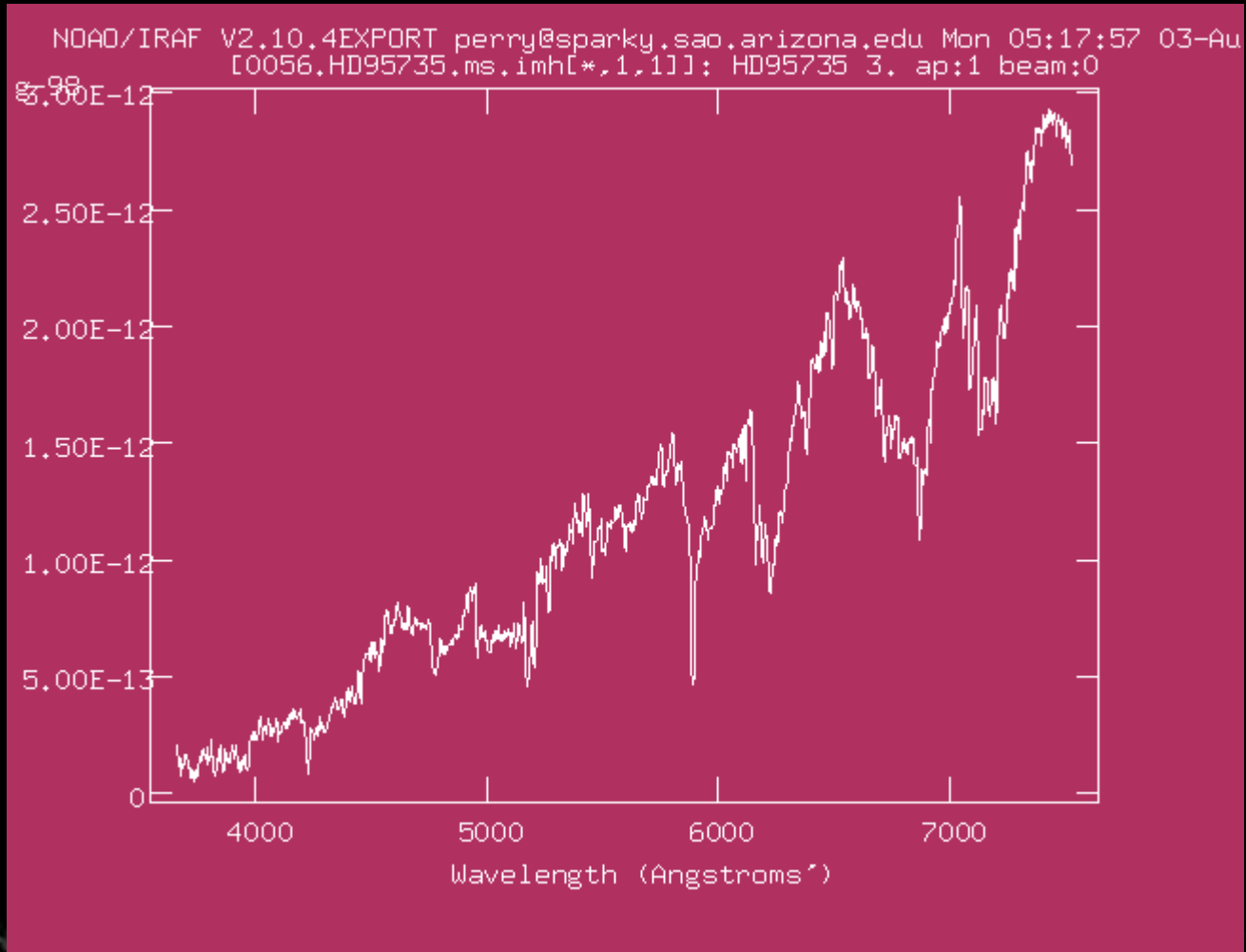
HD109358

GOV



HD95735

M2V



Astronomical Spectroscopy

Analyzing Electromagnetic Spectrum

☉ Composition

- ☉ Spectra line patterns: atoms, ions & molecules

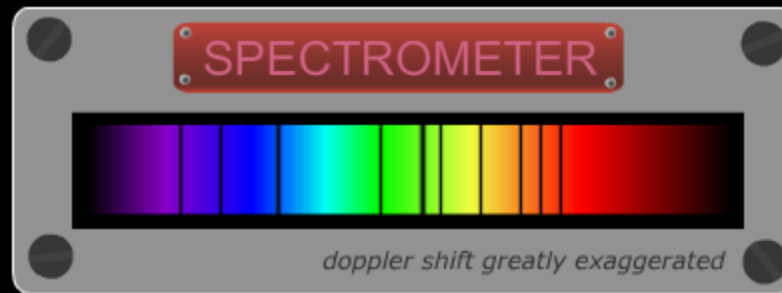
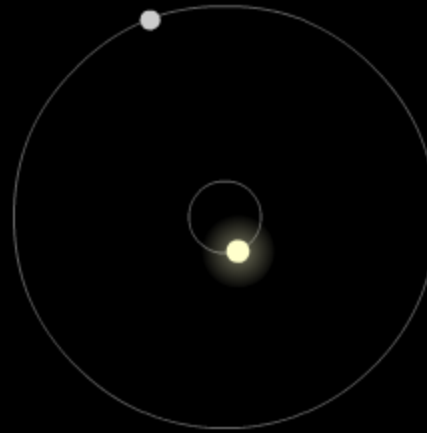
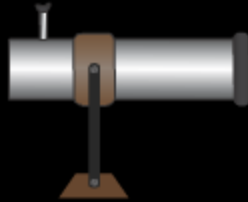
☉ Temperature & density

- ☉ Spectra line patterns: atom states & transitions
- ☉ Stellar classification

➔ ☉ Motions

- ☉ Spectra line Doppler shift

Radial Velocity Spectra



Radial Velocity Spectra

Quasar 3C 273 Redshift Measurement



Quasar 3C 273 Redshift

One 300 second image

The screenshot shows a software interface for astronomical observation. The main window displays a star field with a circled object. A status bar at the bottom of the main window reads: "0'19" 12h29m06.70s +02°03'08.0" * QSO 3C 273.0 mV:12.85 b-v: 0.20 z:0.158 Mabs:-26.9 U-B:-0.87". An "Identification" window is open on the right, displaying the following data:

Star	
QSO	3C 273.0
Visual Magnitude:	12.85
Color Index:	0.20
z:	0.158
Mabs:	-26.9
U-B:	-0.87
J2000 RA: 12h29m06.70s DE:+02°03'08.0"	
Date RA:	12h29m37.94s DE:+01°59'45.7"
My home 2010-3-6 22h15m (TU + -8h00m)	
Sideral Time	: 9h05m
Hour Angle	: 20h36m
Azimuth	: +118°37'
Altitude	: +27°38'
Rise	: 19h33m Azimuth:+86°34'
Culmination	: 1h45m
Set	: 7h56m Azimuth:+273°26'
Distance to the last object	: +00°
21'22.3" PA:59	

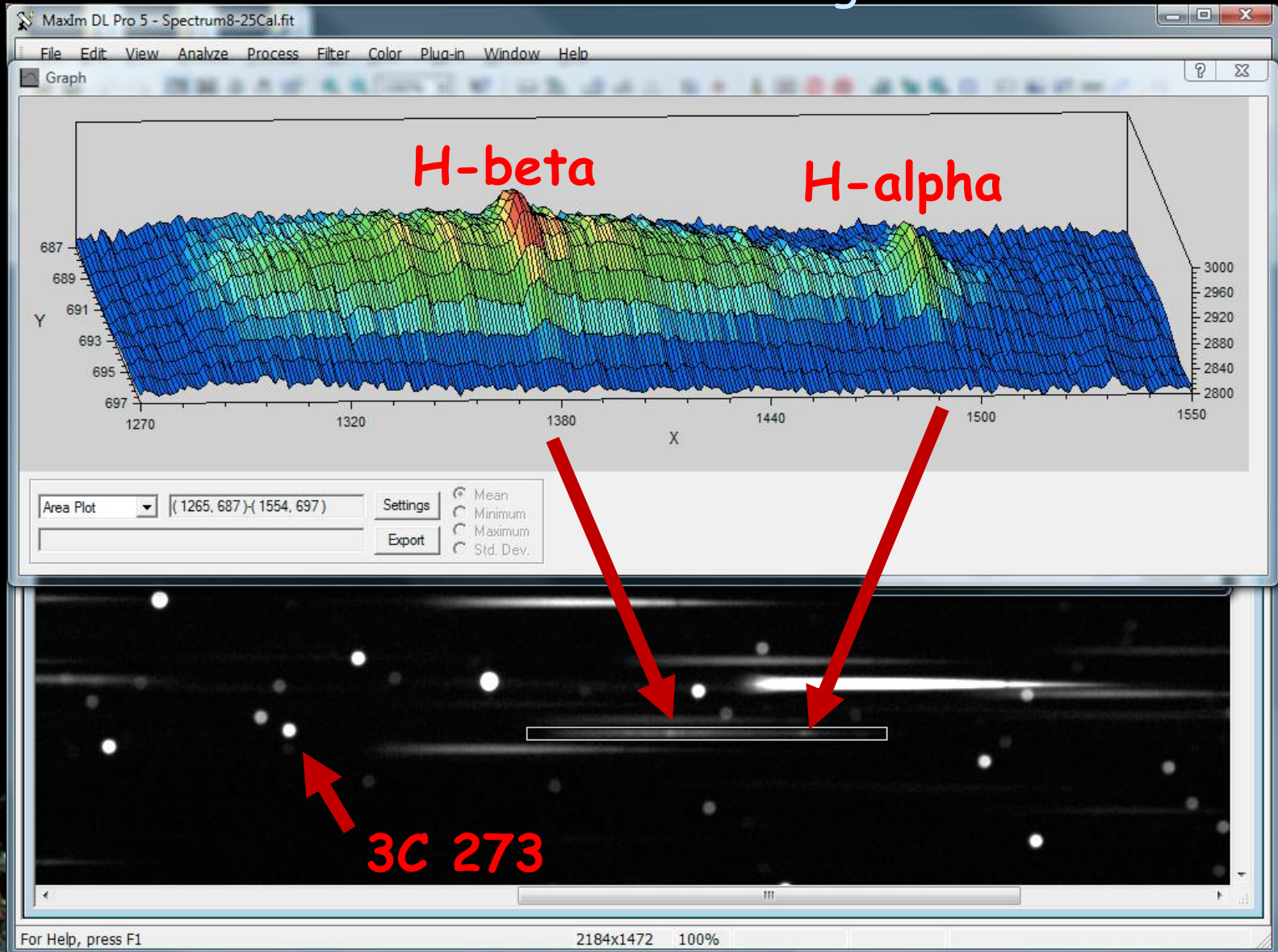
Below the identification window, there are buttons: "Close", "Center object", "Neighbor", and "Clipboard".

At the bottom of the main window, there is a status bar: "Right-click for options, or roll mouse wheel to zoom. CTRL or SHIFT for more options. 2184x1472 100% (1114, 685) i: 4202,000".

Red arrows point to the circled object in the star field, and the text "3C 273" is written in red below the object.

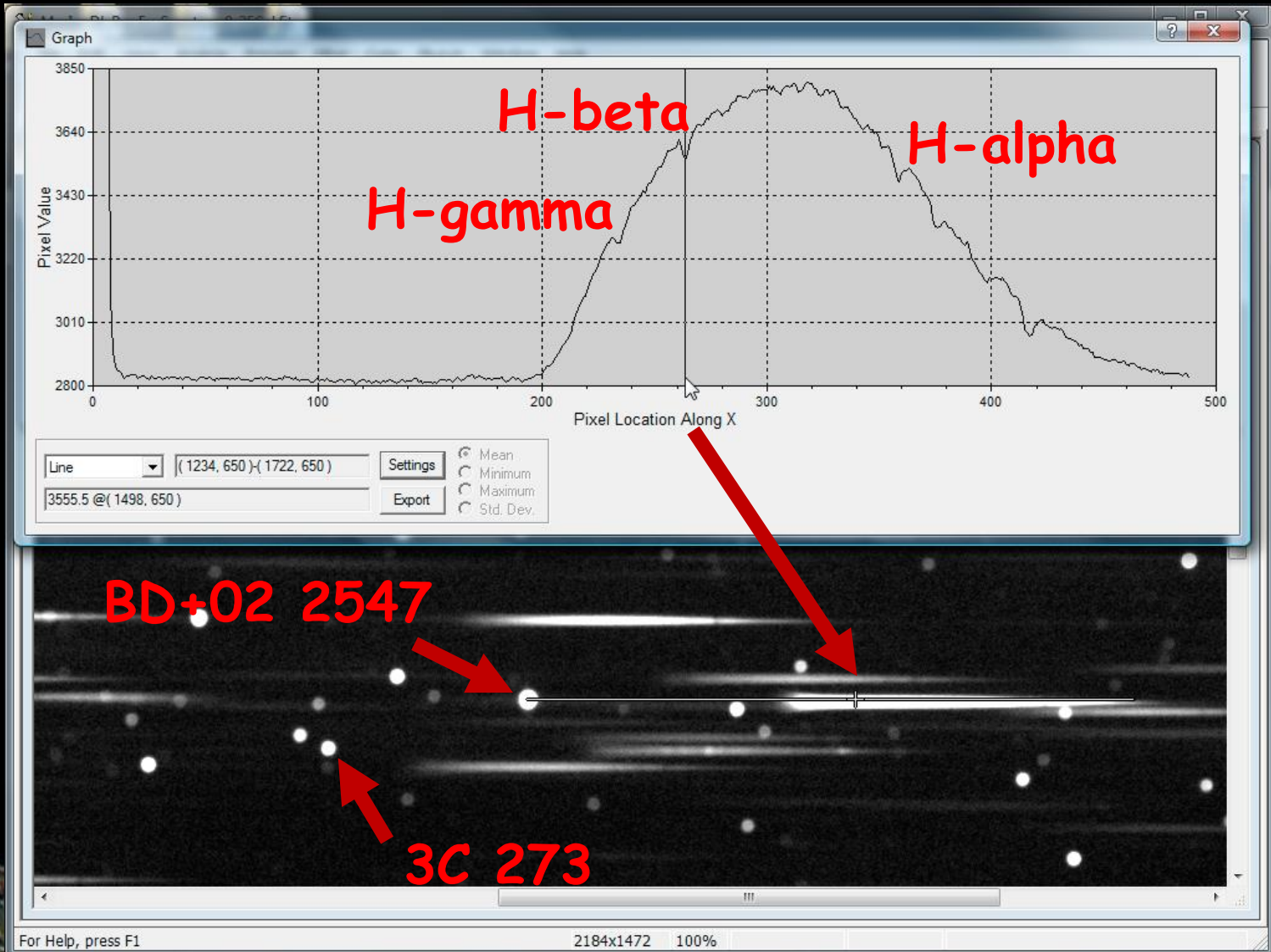
Quasar 3C 273 Redshift

16 x 300 second images



Quasar 3C 273 Redshift

Star BD+02 2547, F5 used for calibration



Quasar 3C 273 Redshift

Redshift $z = 0.158339$

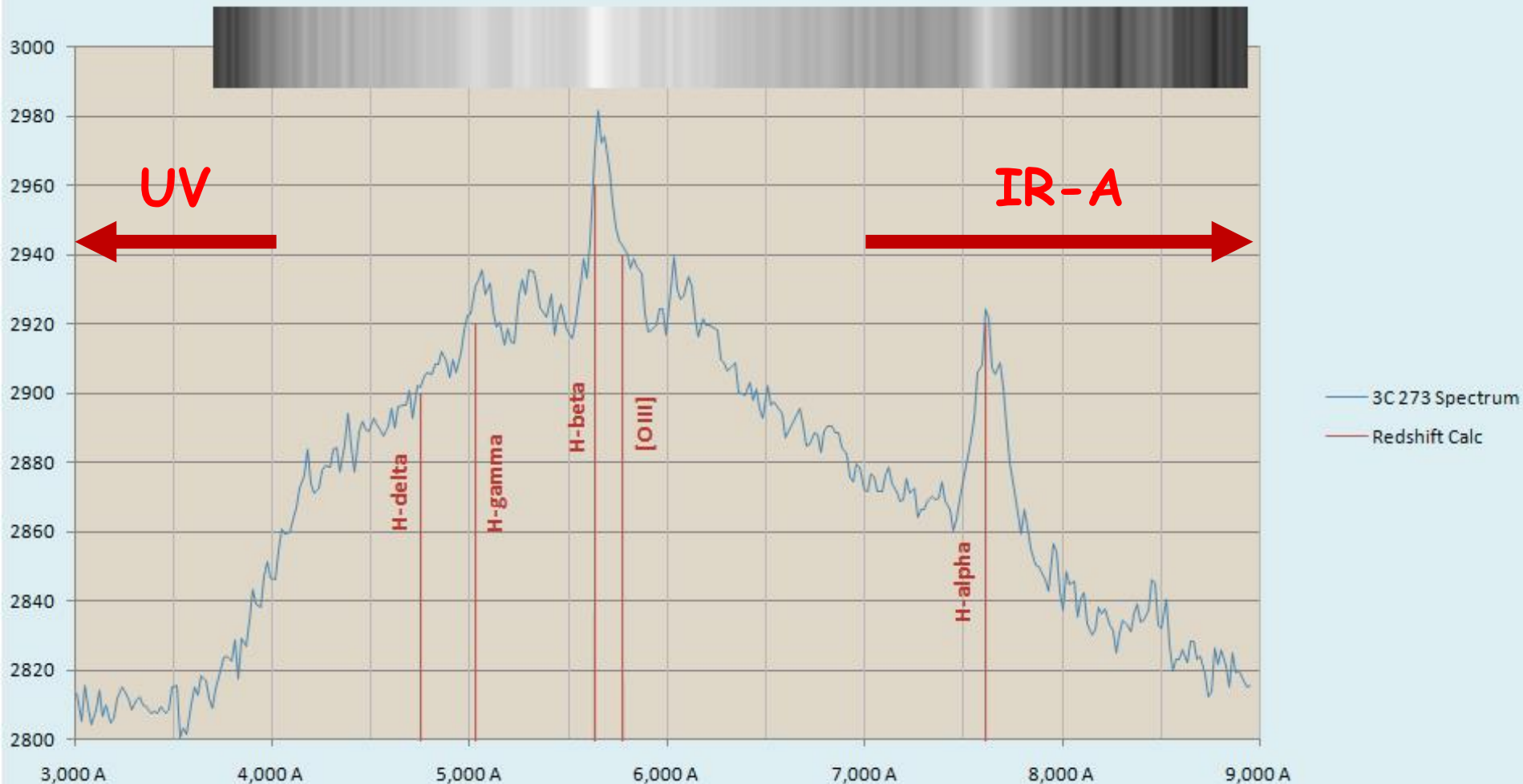
3C 273 Redshift
 $z=0.158339$

$$z = \frac{\lambda_{\text{obsv}} - \lambda_{\text{emit}}}{\lambda_{\text{emit}}}$$

<u>Elements</u>	<u>Emit Wavelength</u>	<u>Redshift Change in Wavelength</u>	<u>Observed Wavelength</u>
H-alpha	6563 Å	1039 Å	7602 Å
[O III]	5007 Å	793 Å	5800 Å
H-beta	4861 Å	770 Å	5631 Å
H-gamma	4340 Å	687 Å	5027 Å
H-delta	4102 Å	650 Å	4752 Å

Quasar 3C 273 Redshift

Observed Quasar 3C 273 Spectrum



Quasar 3C 273

Observed Spectrum Redshift 0.1608

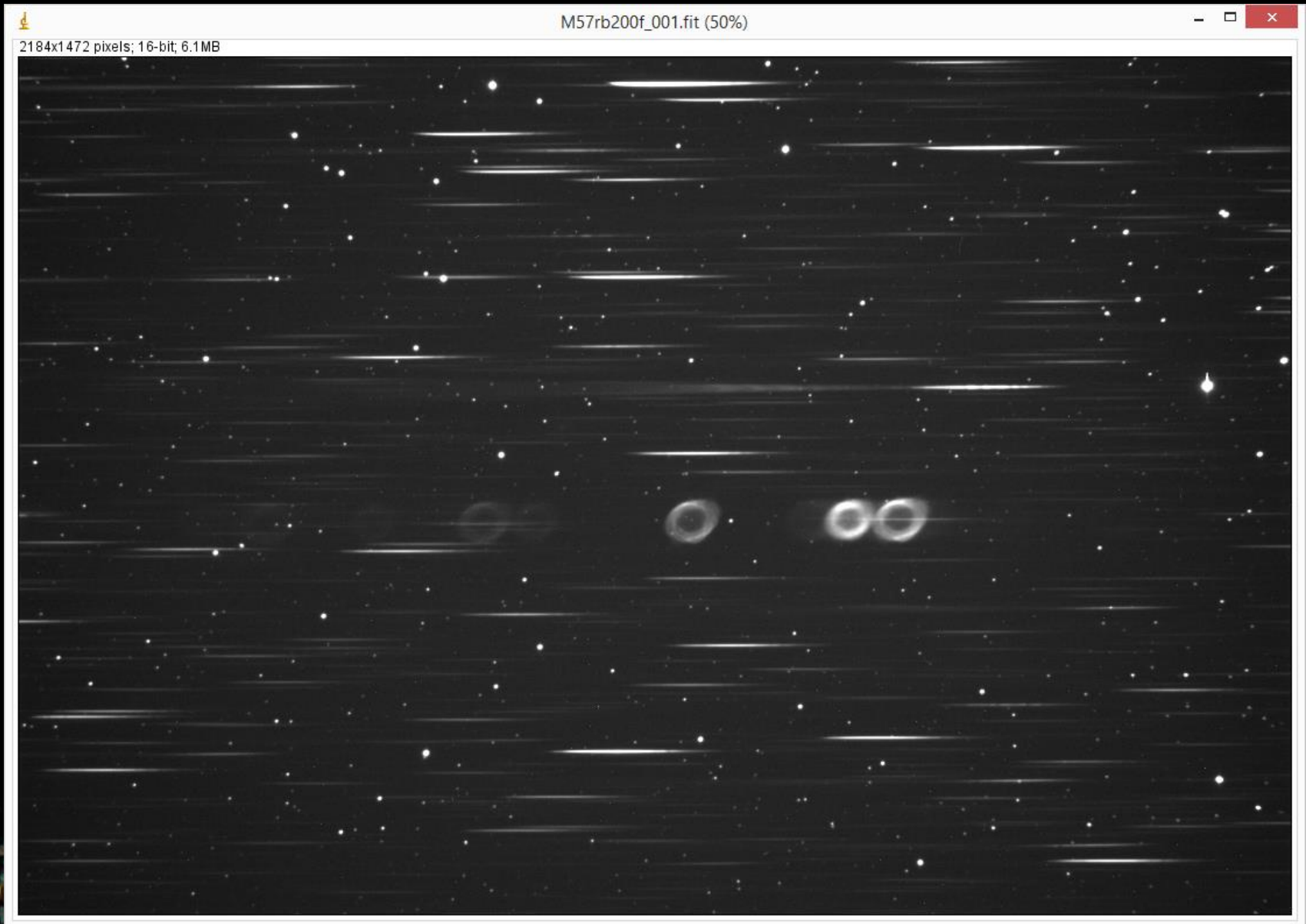
<u>Elements</u>	<u>Emit Wavelength</u>	<u>Observed Wavelength at Peak</u>	<u>Observed Redshift z</u>	<u>Redshift Error z=0.158339</u>	<u>Signal/Noise Ratio at Peak</u>
H-alpha	6563 Å	7609 Å	0.1594	0.6909%	26.28
H-beta	4861 Å	5649 Å	0.1622	2.421%	39.14

The average of the measured H-alpha and H-beta redshifts is $z=.1608$ which is 1.5% higher than $z=0.158339$ in the [NASA/IPAC Extragalactic database](#).

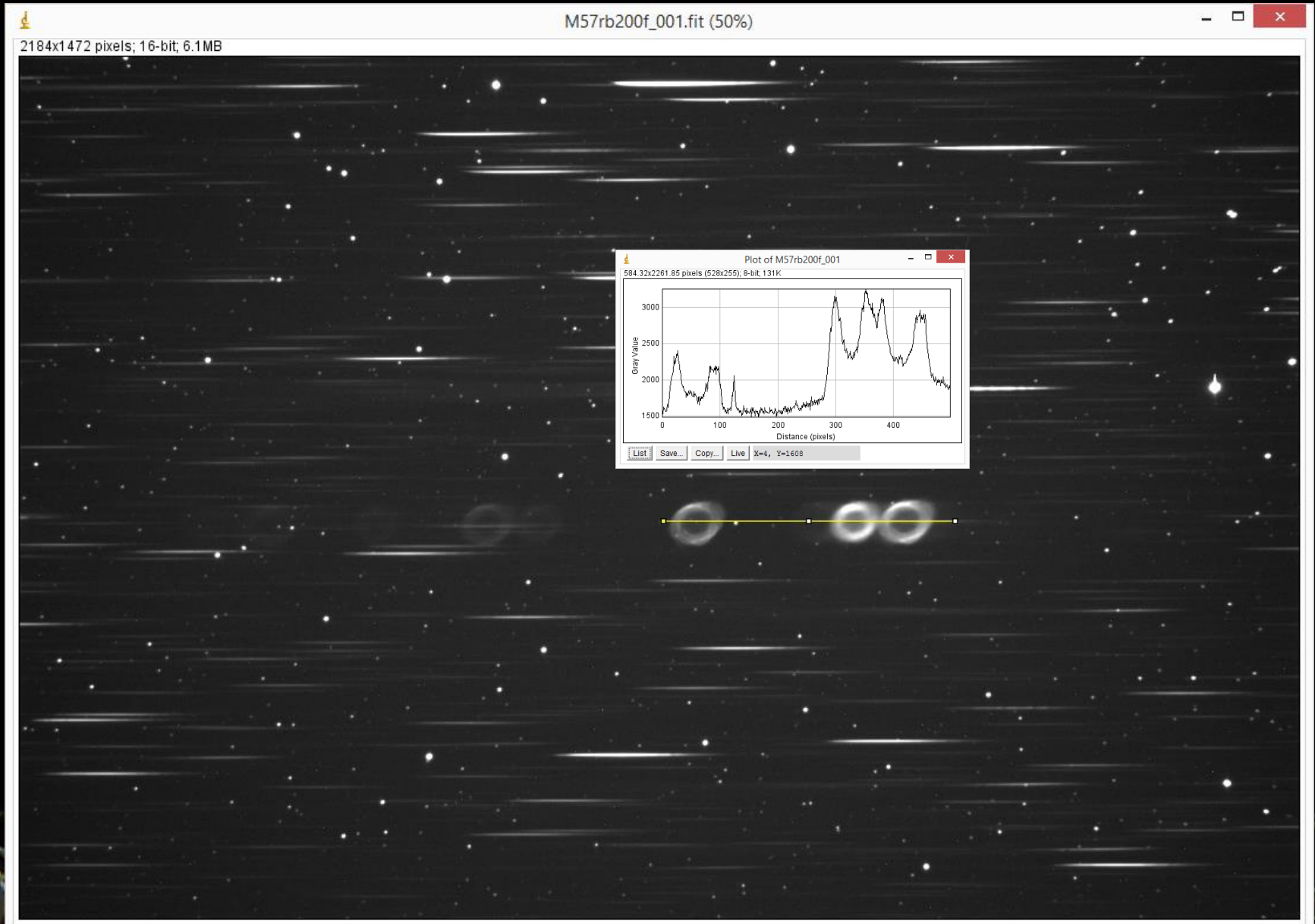
Note: Signal/Noise Ratio at Peak = (Peak-Background Ave)/(Background Std Dev)

H-beta Signal/Noise Ratio at Peak = $(2981.76-2806.47)/(4.478) = 39.14$ S/N

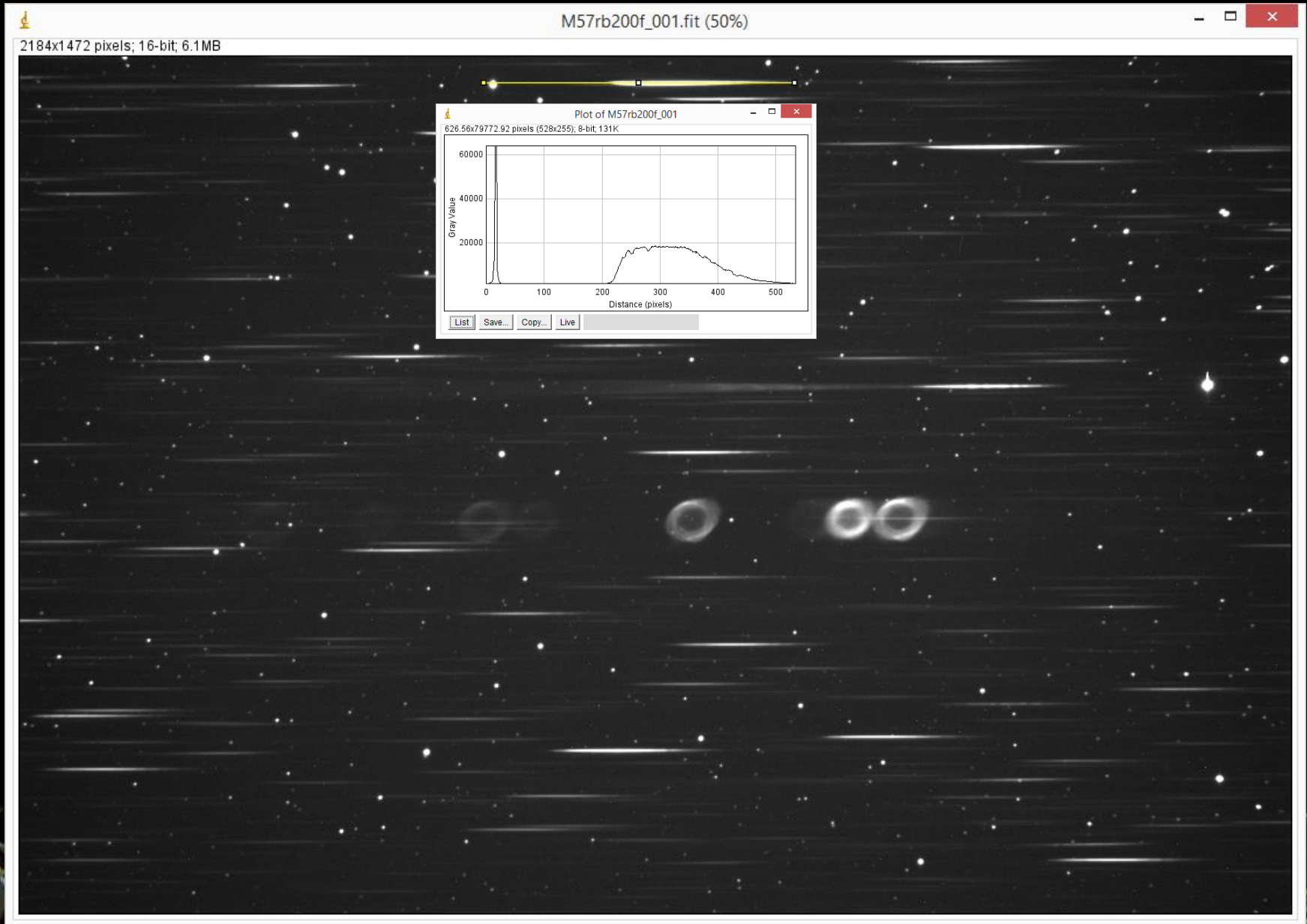
M57 PMO 2014 Sunday Night



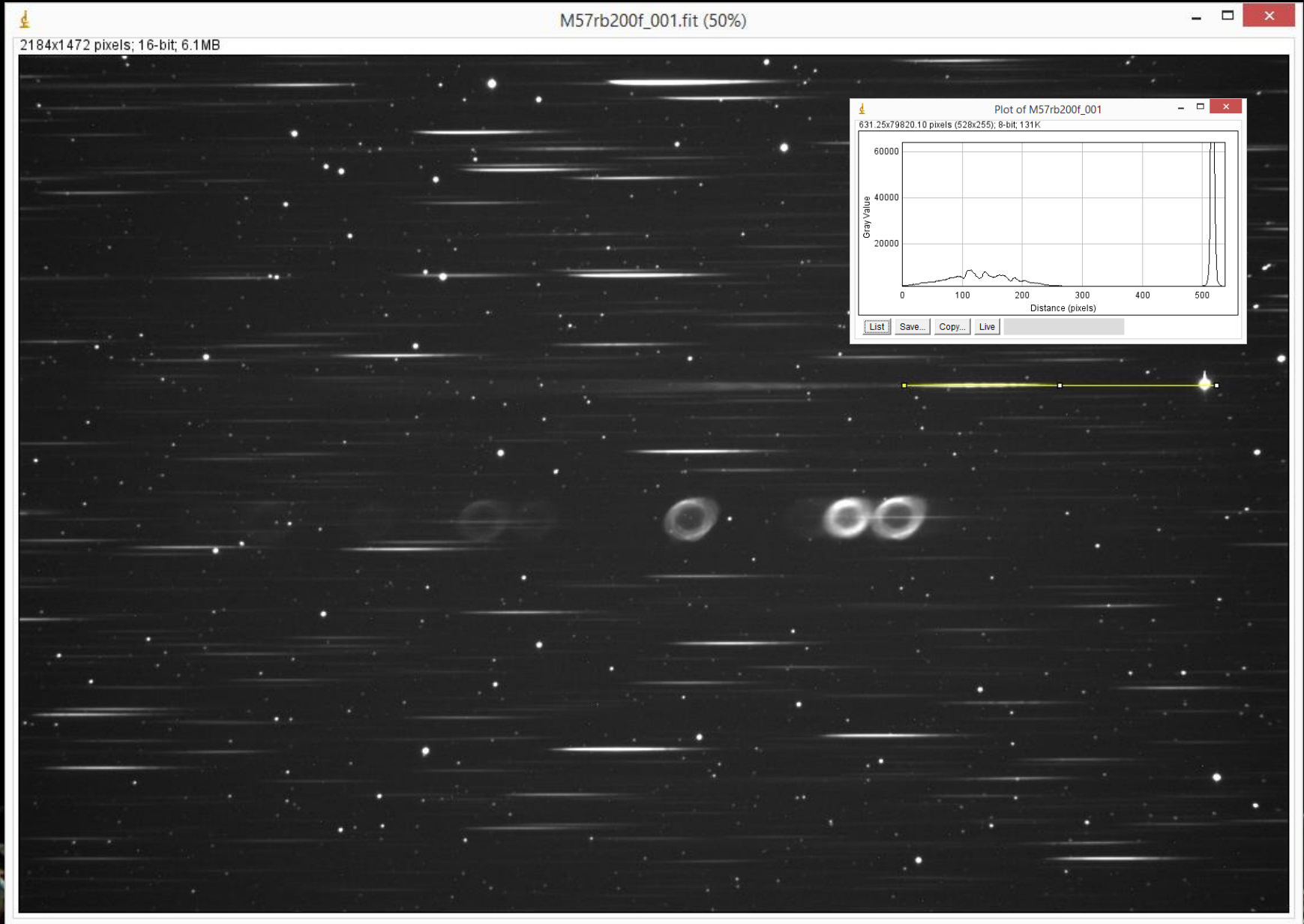
M57 PMO 2014 Sunday Night



M57 PMO 2014 Sunday Night



M57 PMO 2014 Sunday Night



Astronomical Spectroscopy Summary

Analyzing Electromagnetic Spectrum

☉ Composition

- ☉ Spectra line patterns: atoms

☉ Temperature & density

- ☉ Spectra line patterns: atom states & transitions
- ☉ Stellar classification

☉ Motions

- ☉ Spectra line Doppler shift

Credits: <http://astro.unl.edu/>

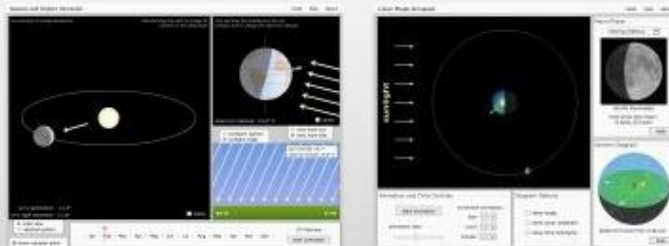
Astronomy Education at the University of Nebraska-Lincoln

Home ClassAction NAAP Labs Interactives

mirror
Contact

The Nebraska Astronomy Applet Project

interactive, simulator-based online laboratories for introductory astronomy



ClassAction

dynamic think-pair-share questions to engage students in the astronomy classroom



About

X close

This simulator is part of the Blackbody Curves & UVB Filters Module of the Nebraska Astronomy Applet Project. Supporting materials and additional astronomy education resources can be found at

<http://astro.unl.edu>

Funding for this work was provided by NSF grants #0231270 and/or #0404988.

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bbExplorer025, 18 July 2007
your player version: WIN 10,0,45,2

<http://www.stargazing.net/david/spectroscopy/links.html>

Spectroscopy Links - Windows Internet Explorer
http://www.stargazing.net/david/spectroscopy/links.html
Light

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Observational Astronomy - Windows Internet Explorer

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Observational Astronomy

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Observational Astronomy



David Haworth

The image shows a screenshot of a web browser displaying the homepage for 'Observational Astronomy' by David Haworth. The browser window title is 'Observational Astronomy - Windows Internet Explorer'. The address bar shows the URL 'http://www.stargazing.net/david/'. The page features a dark, starry background with various celestial objects like galaxies and a comet. At the top, there are navigation links: '<<PREVIOUS - HOME - CONTENTS - NEXT>>' and a 'NEW!' icon. The main title 'Observational Astronomy' is prominently displayed in the center. Below the title, there is an illustration of a person in a red jacket using a telescope. At the bottom of the page, the name 'David Haworth' is written. The browser interface includes a search bar with 'Yahoo! Search', a toolbar with icons for home, RSS, print, page, and tools, and a status bar at the bottom.