Stellar Spectra Classification Exercise

Introduction

This activity allows you to introduce the classification of stellar spectra from a few different perspectives. It utilises actual intensity-plot spectra of stars obtained by the *Sloan Digital Sky Survey* project accessed through SkyServer:
http://skyserver.sdss.org

Details on spectroscopy including how they are obtained and how stars may be classified according to their spectra can be found as part of the *Australia Telescope Outreach and Education* website section on the *Astrophysics* option:
http://outreach.atnf.csiro.au/education/senior/astrophysics/spectroscopytop.html
There are nine pages focusing on spectroscopy that directly address the syllabus requirements. They cover historical background, how we obtain spectra, classification schemes, examples, activities and questions.

Background details on spectroscopy on SkyServer site at:
http://cas.sdss.org/dr3/en/proj/advanced/spectraltypes/

The specific stellar spectra used in this activity are from:
Browse Plate: http://cas.sdss.org/dr3/en/tools/getimg/plate.asp
Plate: 266/51630

The SkyServer website has an online exercise on stellar spectral classification suitable for HSC students at:
http://cas.sdss.org/dr3/en/proj/advanced/spectraltypes/studentclasses.asp

Notes:
The wavelength unit on the SDSS spectra is Å, the angstrom. 1 Å = 1×10^{-10}m.

Types of spectra:

| Type of spectrum	Photographic example
Continuous (or continuum)	
Absorption (dark line)	
Emission (bright line)	

The Balmer Series (visible H lines)

Balmer line	Wavelength (nm)
Hα	656.3
Hβ	486.1
Hγ	434.1
Hδ	410.2
Hε	397.0

Wien's Law and Blackbody Curves

The behaviour of most stars approximates that of black body radiators. This means that they emit some energy at each wavelength but also have a peak wavelength and region in which they emit most of their energy.
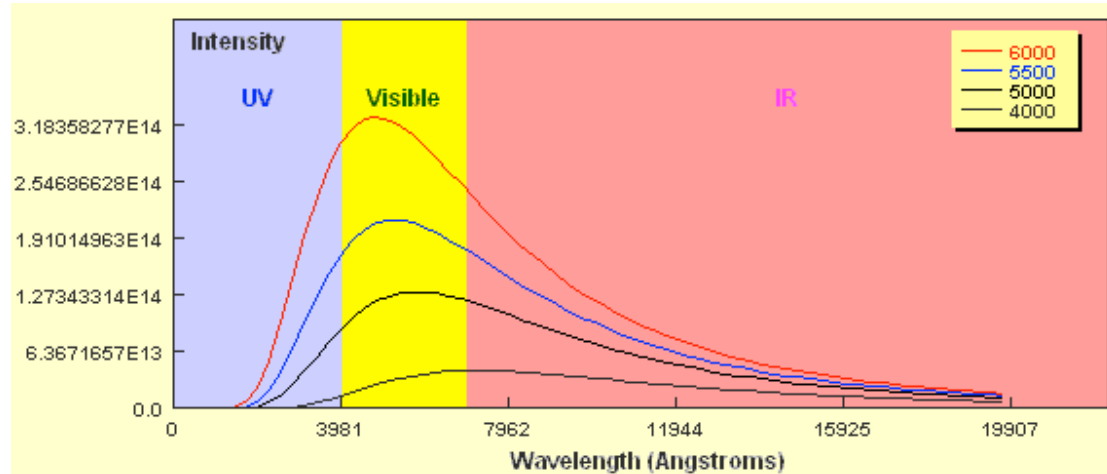
In the early 1890s Wilhelm Wien investigated thermodynamics and coined the term *black body* for an ideal radiator. He discovered that the wavelength of maximum energy emitted from a perfect black body was inversely proportional to the temperature of the body, λ_{max} is proportional to $1/T$. This relationship is known as Wien's Law in his honour.
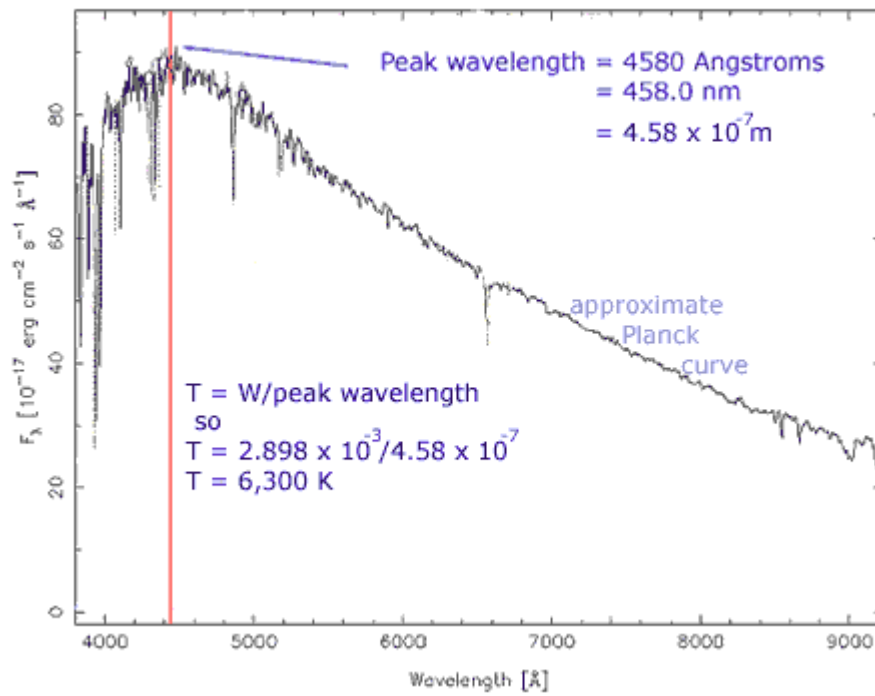
$$\lambda_{max} \propto \frac{1}{T}$$

and

$$\lambda_{max} = \frac{W}{T}$$

Equation 1: **Wien's Law**, where λ_{max} is the peak wavelength, T is the effective temperature of the black body and W is a constant called Wien's Constant and has a value of 2.898 x 10⁻³ for λ_{max} in meters and T in kelvins.

(Note: This equation is not explicitly required for the NSW HSC course)
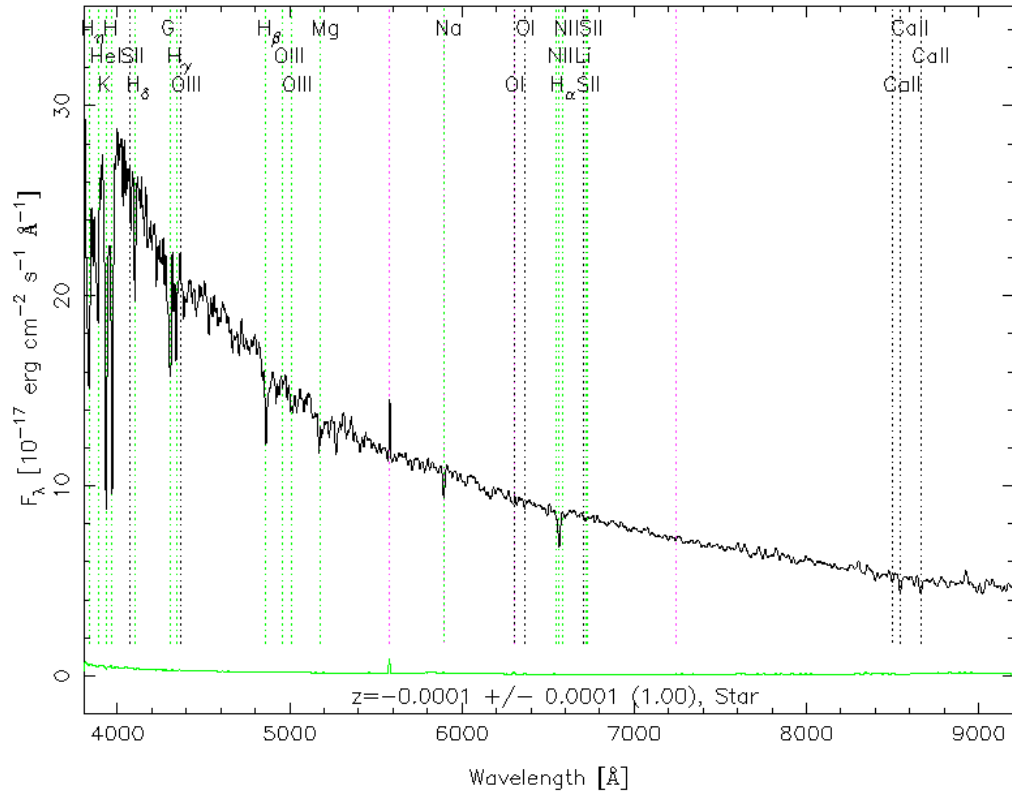
Wien's Law is a highly significant relationship. He used it to estimate the effective temperature of the Sun at 6,000 K which was much closer than the previous estimate of 10,000 K predicted using the Stefan-Boltzmann law of radiation. The value of Wien's relationship is that if you can measure the wavelength of maximum intensity from a spectrum, you can use it to calculate a value for the effective temperature. let us see how this works in the example below. Remember, this is an actual stellar spectrum so it approximates a black body and has absorption lines in it rather than being a perfect continuum Planck curve.
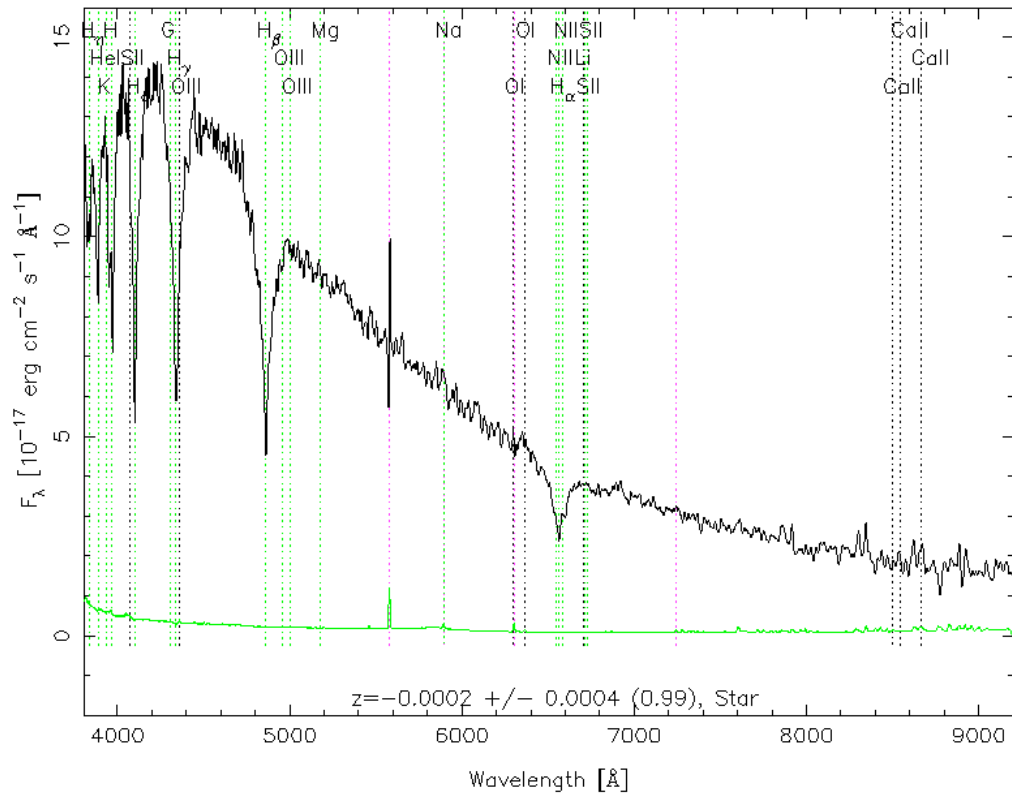
Using Wien's Law to Calculate Stellar Temperature

Peak wavelength = 4580 Angstroms
= 458.0 nm
= 4.58×10^{-7} m

approximate
Planck
curve

T = W/peak wavelength
so
T = $2.898 \times 10^{-3}/4.58 \times 10^{-7}$
T = 6,300 K

A RA=147.04790, DEC=−0.32770, MJD=51630, Plate= 266, Fiber= 21

z=−0.0001 +/− 0.0001 (1.00), Star

B RA=147.32107, DEC=−0.00658, MJD=51630, Plate= 266, Fiber= 37

z=−0.0002 +/− 0.0004 (0.99), Star

C RA=145.28412, DEC= 0.70630, MJD=51630, Plate= 266, Fiber=344

z= 0.0001 +/− 0.0001 (1.00), Star
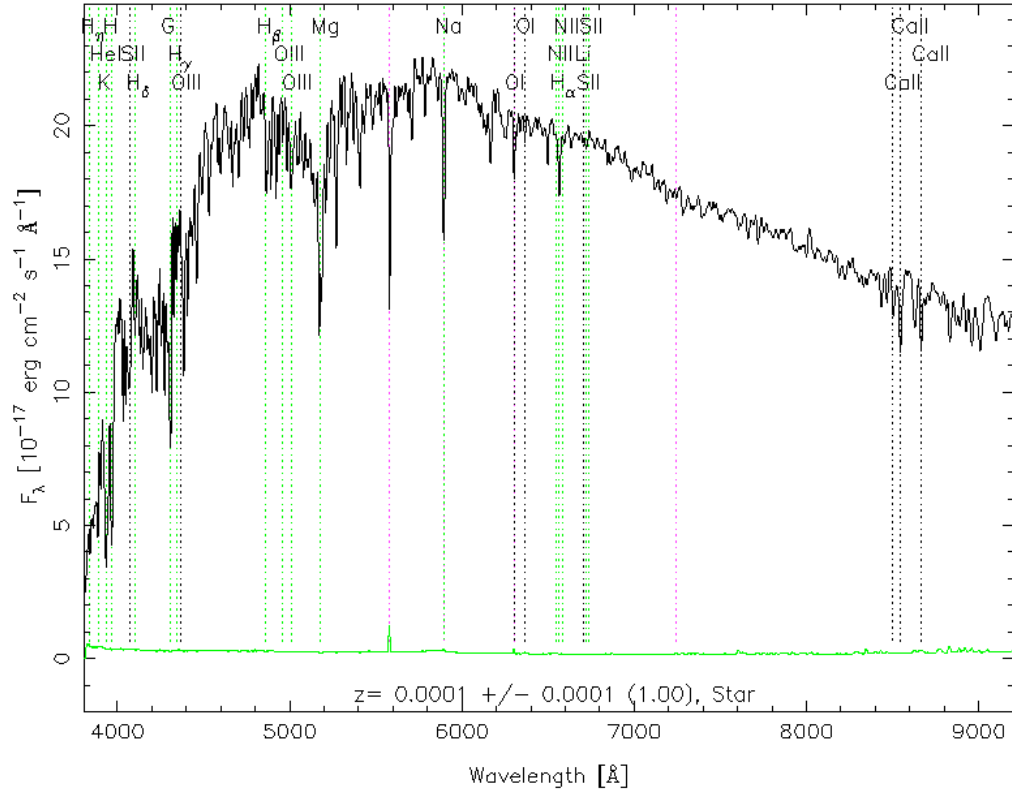
D RA=145.44053, DEC=−0.72904, MJD=51630, Plate= 266, Fiber=259

z=−0.0000 +/− 0.0001 (1.00), Star

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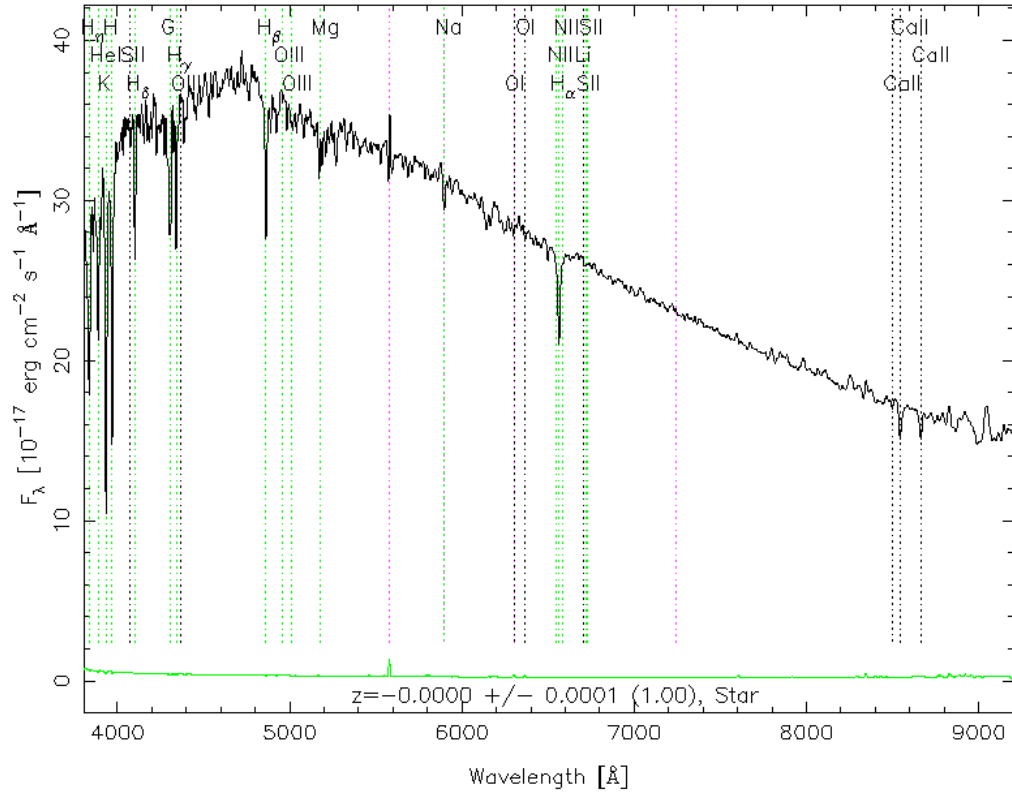
E RA=145.63729, DEC= 0.37330, MJD=51630, Plate= 266, Fiber=390

z=−0.0001 +/− 0.0001 (1.00), Star
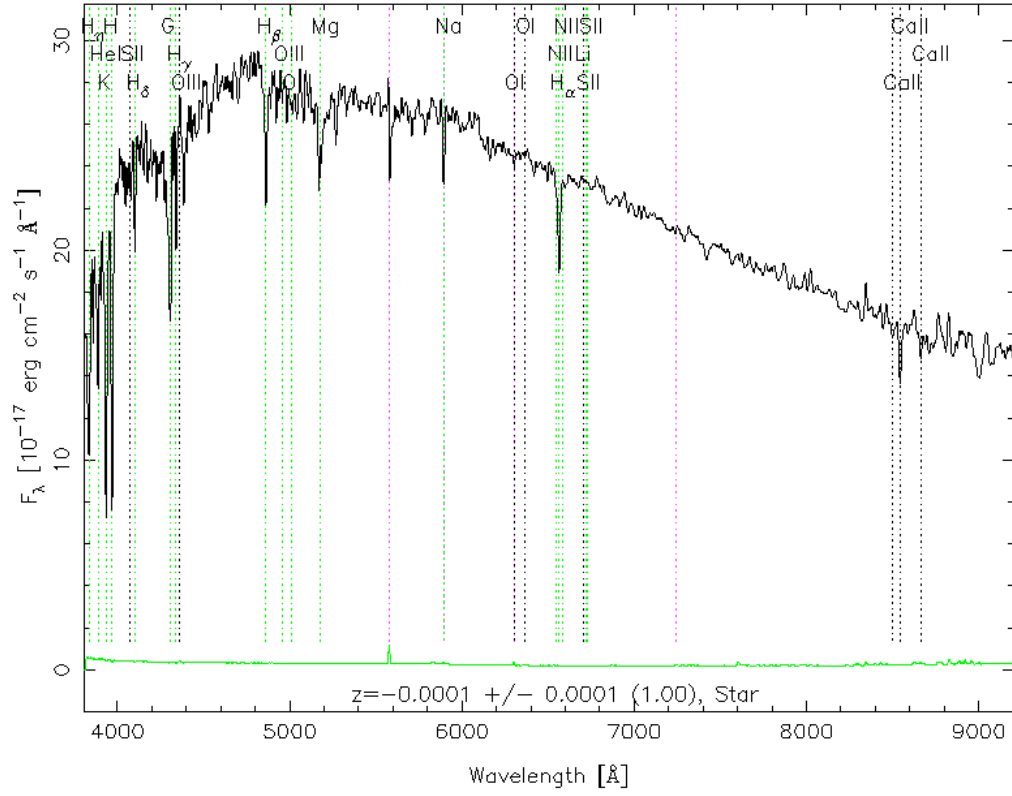
F RA=158.99202, DEC= 0.29401, MJD=51957, Plate= 273, Fiber=589

z= 0.0001 +/− 0.0001 (1.00), Star
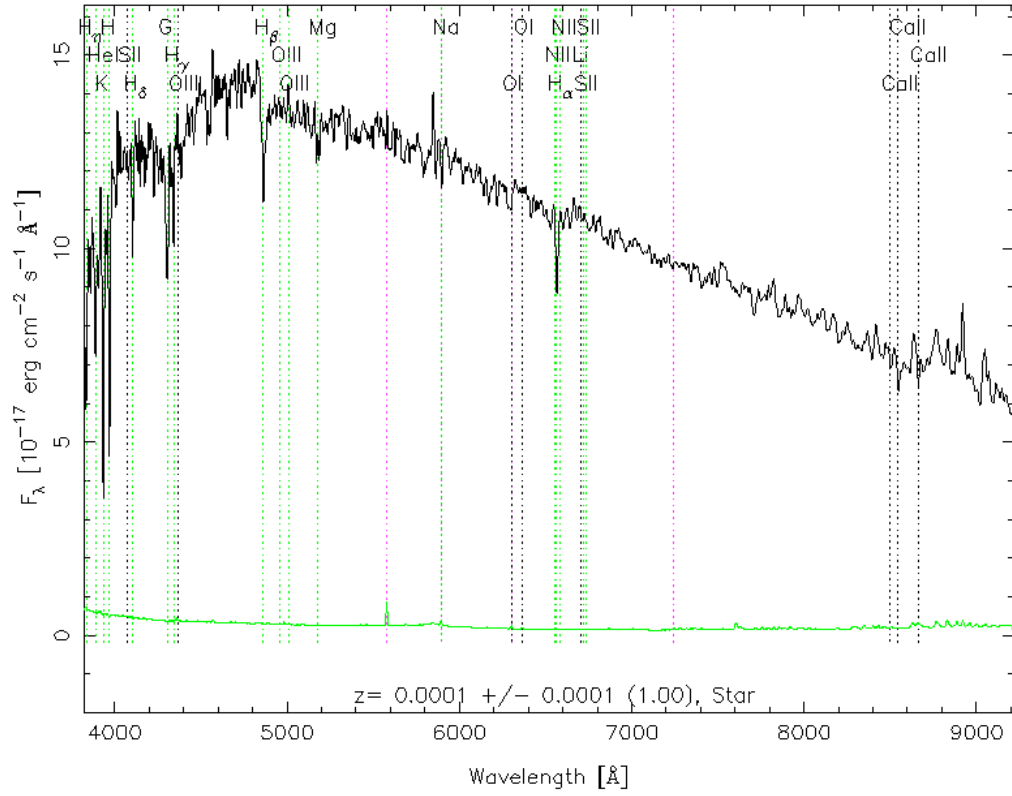
G RA=157.22871, DEC=−0.93284, MJD=51957, Plate= 273, Fiber=245

z= 0.0001 +/− 0.0000 (1.00), StarLate

Wavelength [Å]
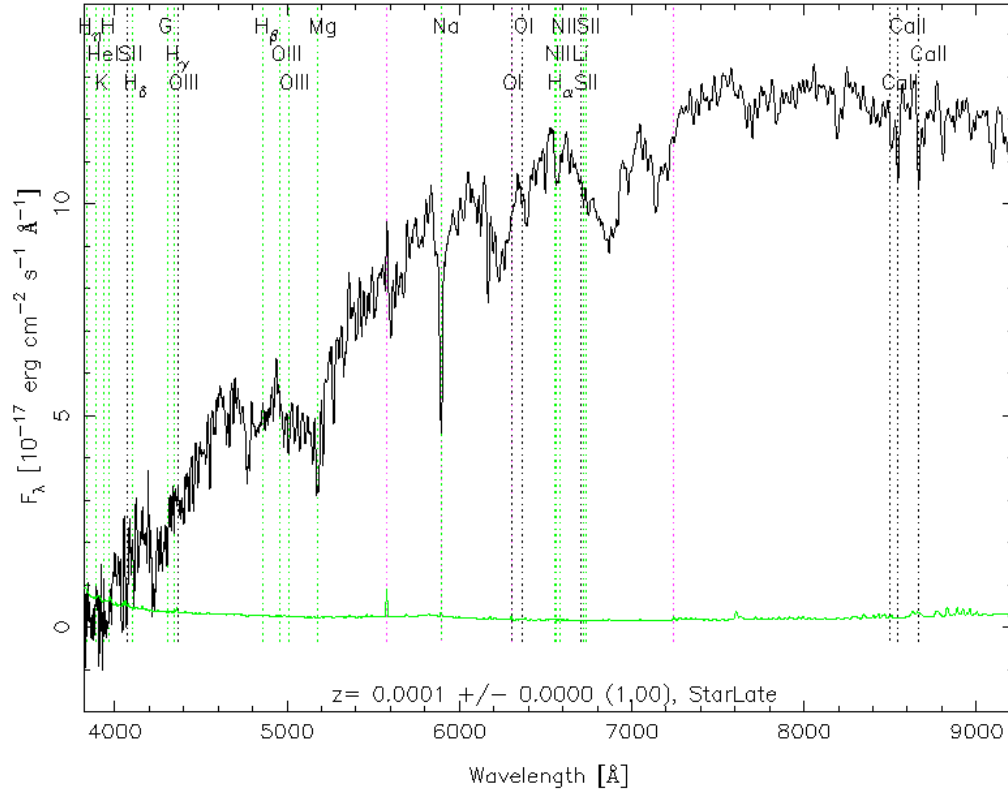
H RA=146.49713, DEC= 0.74242, MJD=51630, Plate= 266, Fiber=539

z= 0.0005 +/− 0.0001 (1.00), Star

Wavelength [Å]
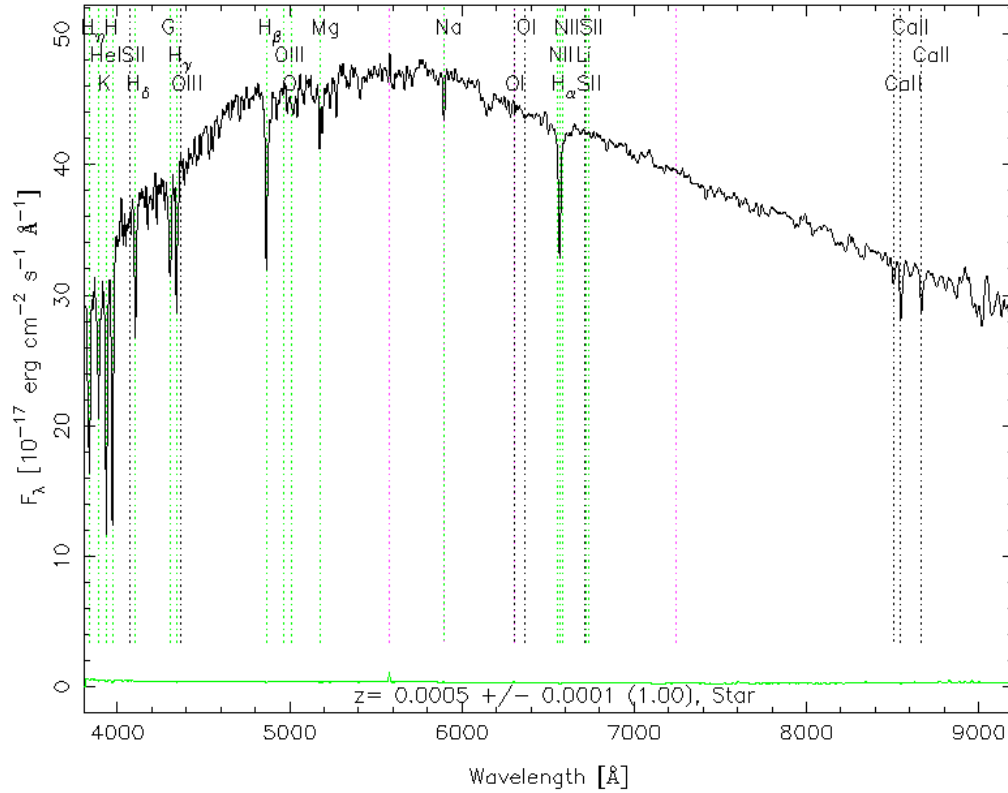
I   RA=146.13033, DEC=−0.65936, MJD=51630, Plate= 266, Fiber= 98

z= 0.0001 +/− 0.0002 (0.99), Star
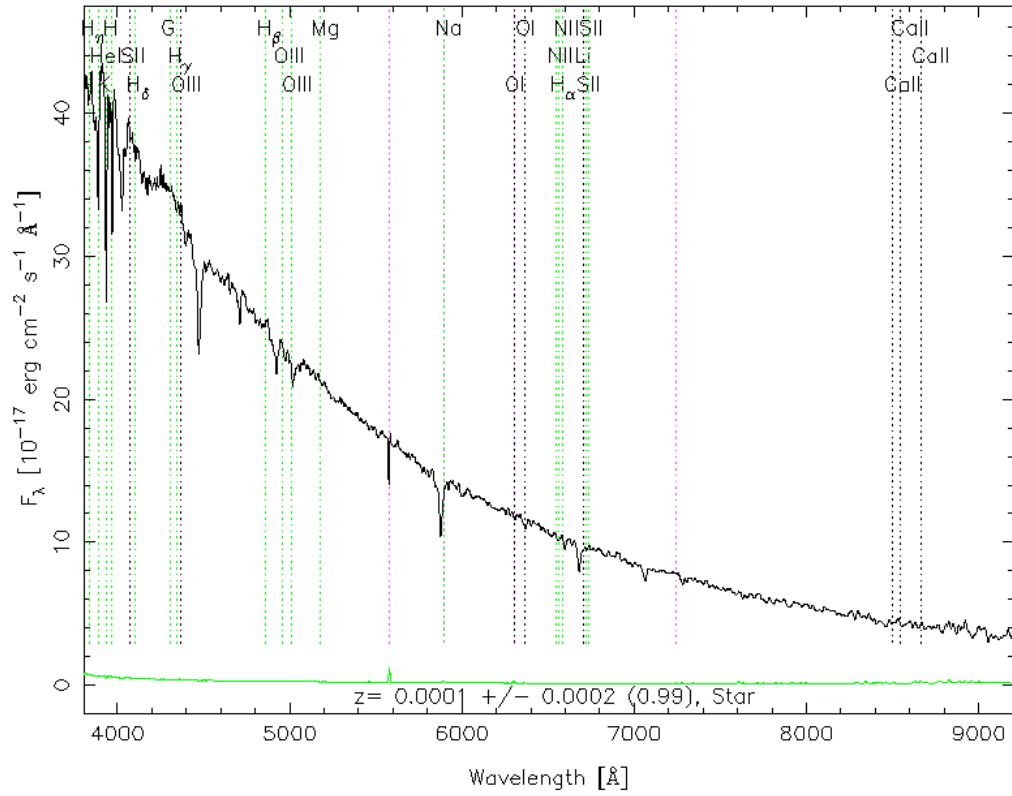
J   RA=146.06230, DEC= 0.50312, MJD=51630, Plate= 266, Fiber=483

z= 0.0002 +/− 0.0001 (1.00), Star
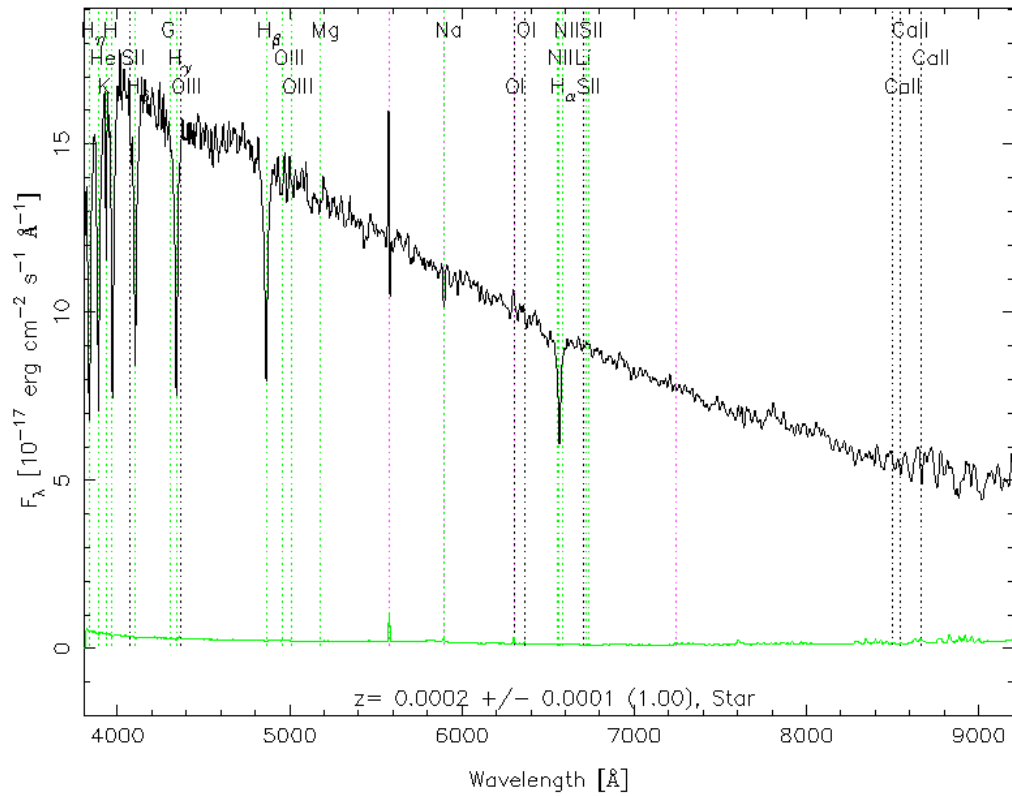
K   RA=145.32060, DEC=−0.25286, MJD=51630, Plate= 266, Fiber=302

z= 0.0520 +/− 0.0001 (q.99), Galaxy
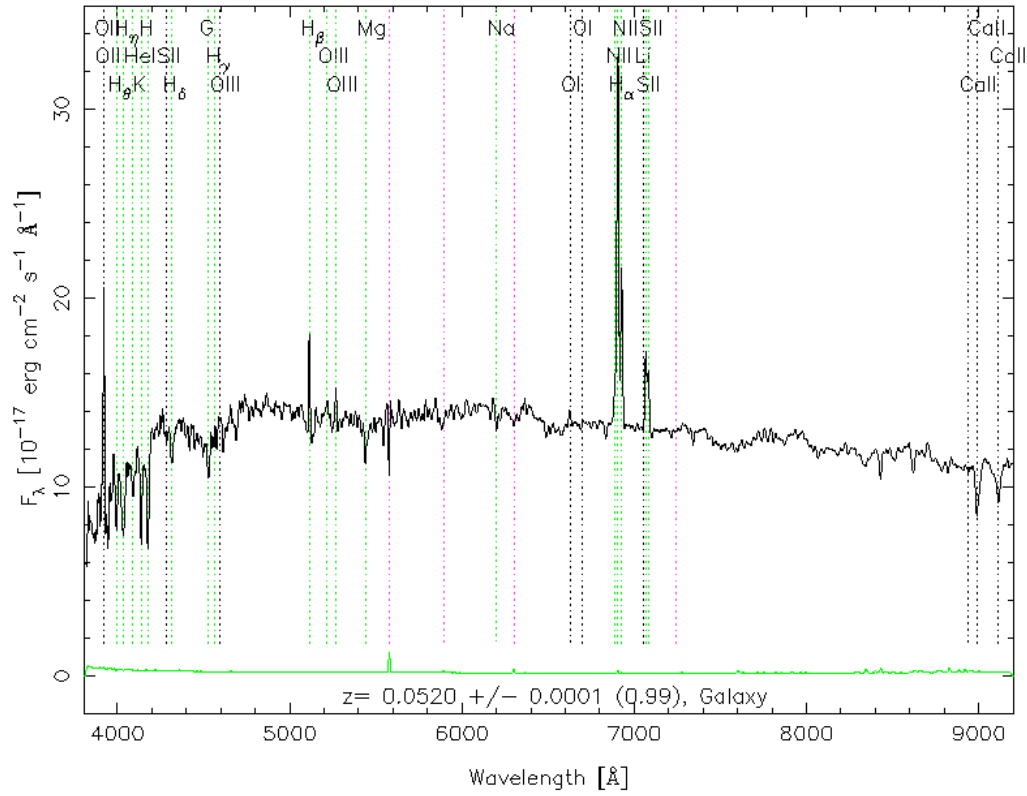
L   RA=145.25355, DEC=−0.10723, MJD=51630, Plate= 266, Fiber=310

z= 0.4847 +/− 0.0002 (q.99), Galaxy
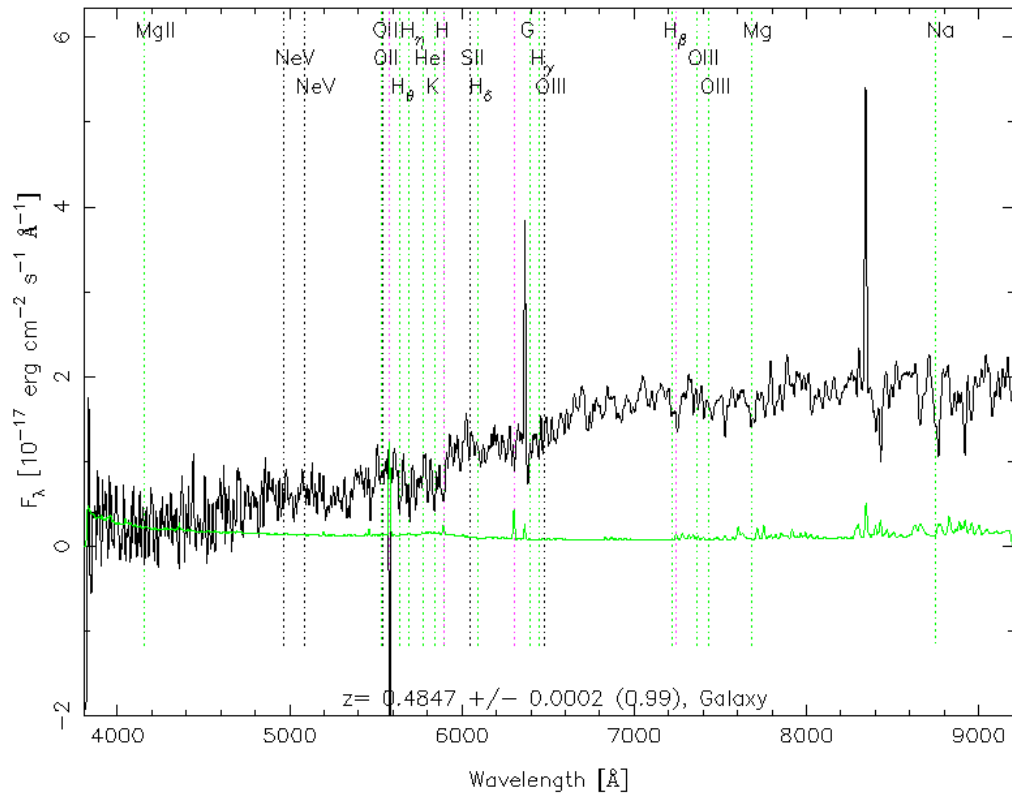
M RA=146.22601, DEC=−0.72510, MJD=51630, Plate= 266, Fiber= 92

Ly$_\alpha$ CII HeII CIII CII
NV SilV+OIV OIII NelV
OI CIV AlIII

F_λ [10^{-17} erg cm^{-2} s^{-1} Å^{-1}]

Wavelength [Å]

z= 2.2905 +/− 0.0016 (1.00), QSO
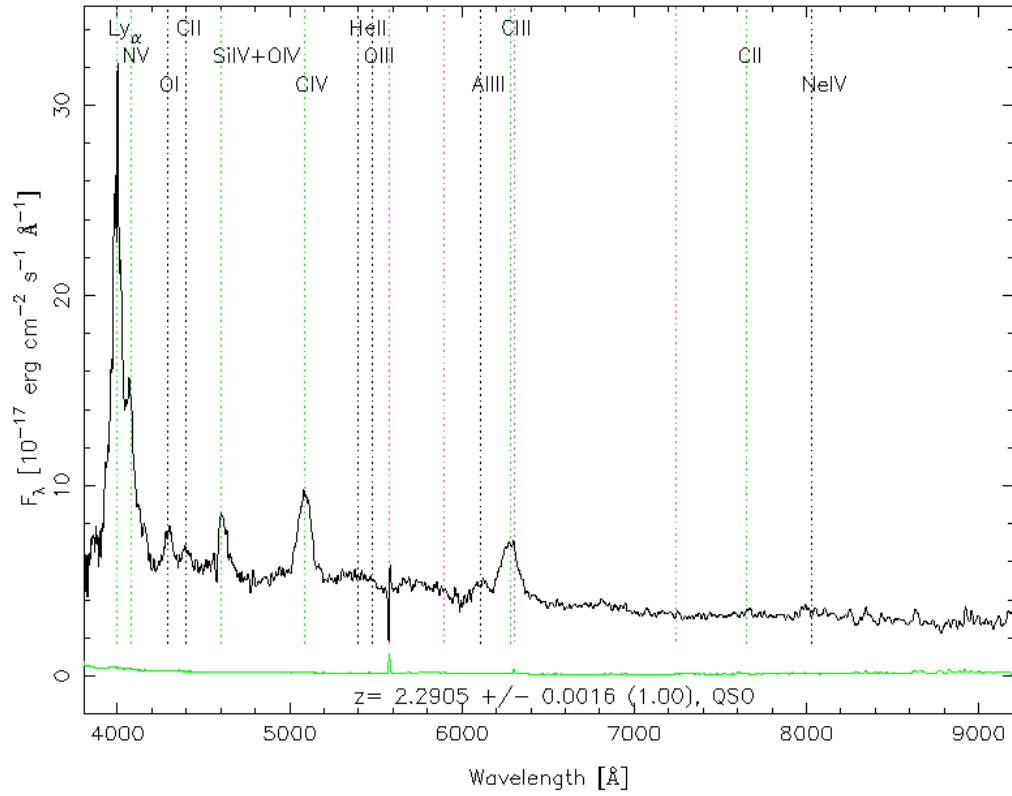
N RA=145.23112, DEC= 0.97447, MJD=51630, Plate= 266, Fiber=340

F_λ [10^{-17} erg cm^{-2} s^{-1} Å^{-1}]

Wavelength [Å]

z=−9999.0000 +/− −9999.0000 (0.00), Sky

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