Unit 4 Assignment: Stellar Spectroscopy Analysis

Name: ___________________________________

Introduction

In this assignment, you will act as an astronomer analyzing real stellar spectra. This two-part activity will guide you through determining the temperatures of stars using Wien's Law and identifying the chemical composition of stars by matching their absorption lines to known elements. You will use real astronomical data, making your work similar to what professional astronomers do!

- In **Part 1**, you will calculate the temperatures of 10 stars from their spectra.
- In **Part 2**, you will compare the absorption lines of 5 stars to elemental lines to determine the stars' chemical composition.

Part 1: Determining Stellar Temperatures Using Wien's Law

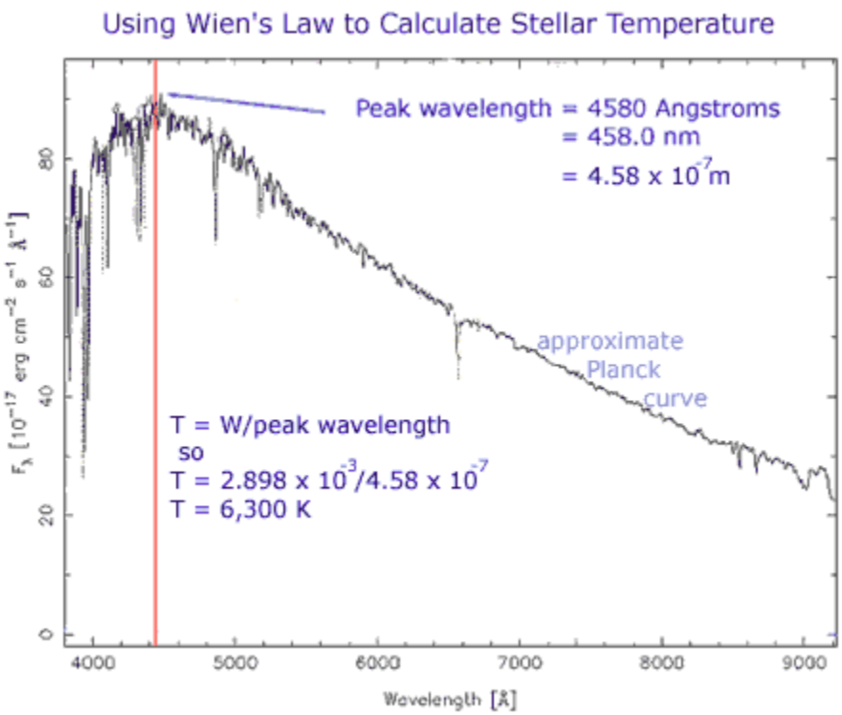
Stars emit light across a range of wavelengths, and the peak wavelength of their emission can help us determine their temperature. Using Wien's Displacement Law, we can calculate a star's temperature based on the wavelength at which the spectrum peaks.

$$T = \frac{b}{\lambda_{\text{max}}}$$

Where:

- T is the temperature in Kelvin (K)
- $b = 2.898 \times 10^{-3}$ m · K, which is Wien's constant
- λ_{max} is the peak wavelength in meters

Example Calculation



Your Task

You will find 10 stellar spectra labeled A–J in the Data section at the end of this document. Identify the peak wavelength for each spectrum and use Wien's Law to calculate the temperature of each star.

Hint: Pay close attention to the wavelength units!

Star	Peak Wavelength (nm)	Peak Wavelength (m)	Temperature (K)
A			
B			
C			
D			
E			
F			
G			
H			
I			
J			

Analysis Questions Part 1

1. **Identifying Trends:** After calculating the temperature of all 10 stars, what general trend do you observe between the temperature and the shape of the spectrum? (i.e. How do cooler stars differ from hotter stars in terms of their emitted light?)

2. **Wien's Law Application:** Calculate the approximate wavelength of peak emission for a star with a temperature of 7500 K. Which part of the spectrum (ultraviolet, visible, infrared) is the peak emission?

3. **Visible Light:** Based on what you know about blackbody radiation and stellar spectra, why do you think humans evolved to see light in the wavelength range of 380 to 700 nanometers?

4. **Temperature and Luminosity:** Two stars have the same temperature, but Star B has a radius that is four times larger than Star C. How would the luminosity (total energy emitted) of Star B compare to Star C? Use your understanding of temperature, luminosity, and star radius to explain your answer.

Part 2: Identifying Elements in Stars Using Absorption Lines

Each element produces a unique set of spectral lines, acting like a "fingerprint" that helps us identify what elements are present in a star. By comparing the absorption lines from stars to known element spectra, we can determine the chemical composition of the stars.

Element Spectra

In the Data section, you will find the emission spectra of seven elements commonly found in stars: Hydrogen, Helium, Neon, Sodium, Lithium, Magnesium, and Iron. These spectra will be used to identify elements in the stars' absorption spectra.

Your Task

In the Data section, you will also find the absorption line spectra of five stars labeled Star 1–5. Compare the absorption lines of each star to the element spectra and identify which elements are present in each star.

Record the elements present in each star by checking the boxes in the table below.

Element	Star 1	Star 2	Star 3	Star 4	Star 5
Hydrogen					
Helium					
Neon					
Sodium					
Lithium					
Magnesium					
Iron					

Analysis Questions Part 2

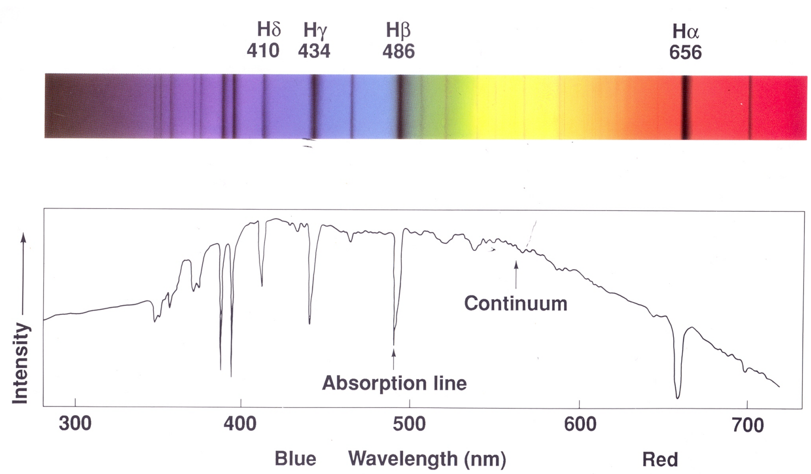
1. **Spectroscopy Importance:** Why is spectroscopy an important tool for studying stars that are light-years away?

2. **Common Elements:** Are there any elements present in all five stars? Why might some elements be found in every star, while others are only found in some stars?

3. **Comparing Stars:** Do any of the stars contain all seven elements? If so, what can you infer about these stars compared to others that contain fewer elements?

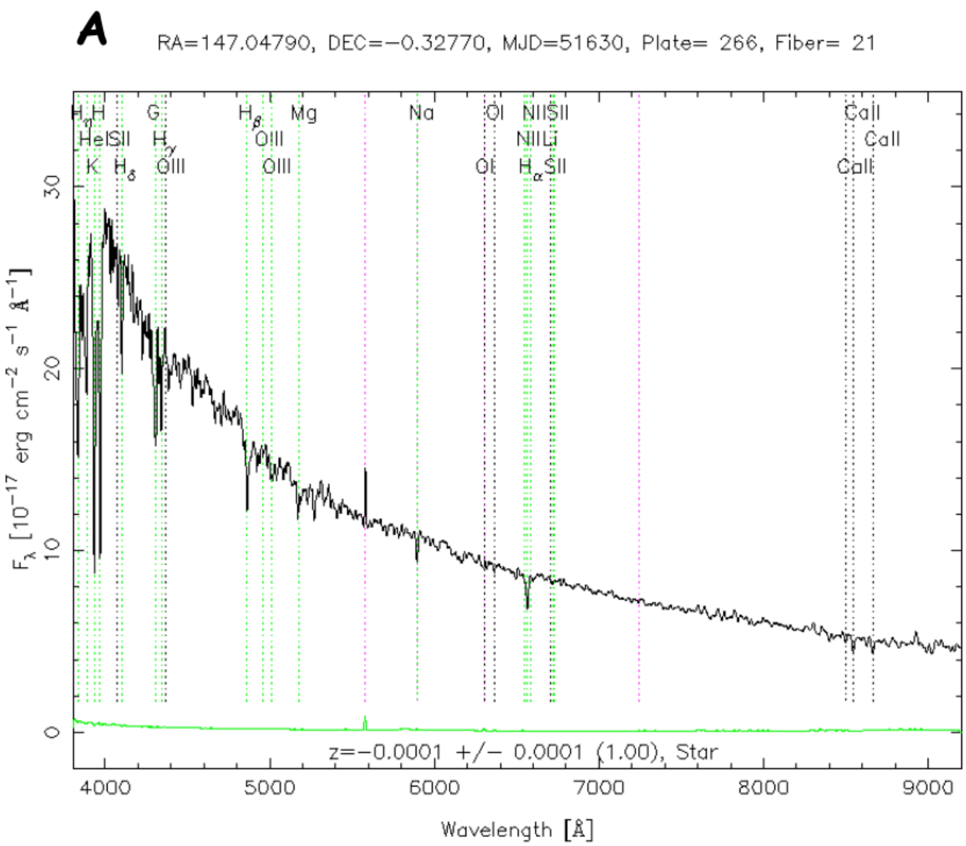
4. **Elemental Fingerprints:** Why is it important for astronomers to study and understand the emission spectra of individual elements?

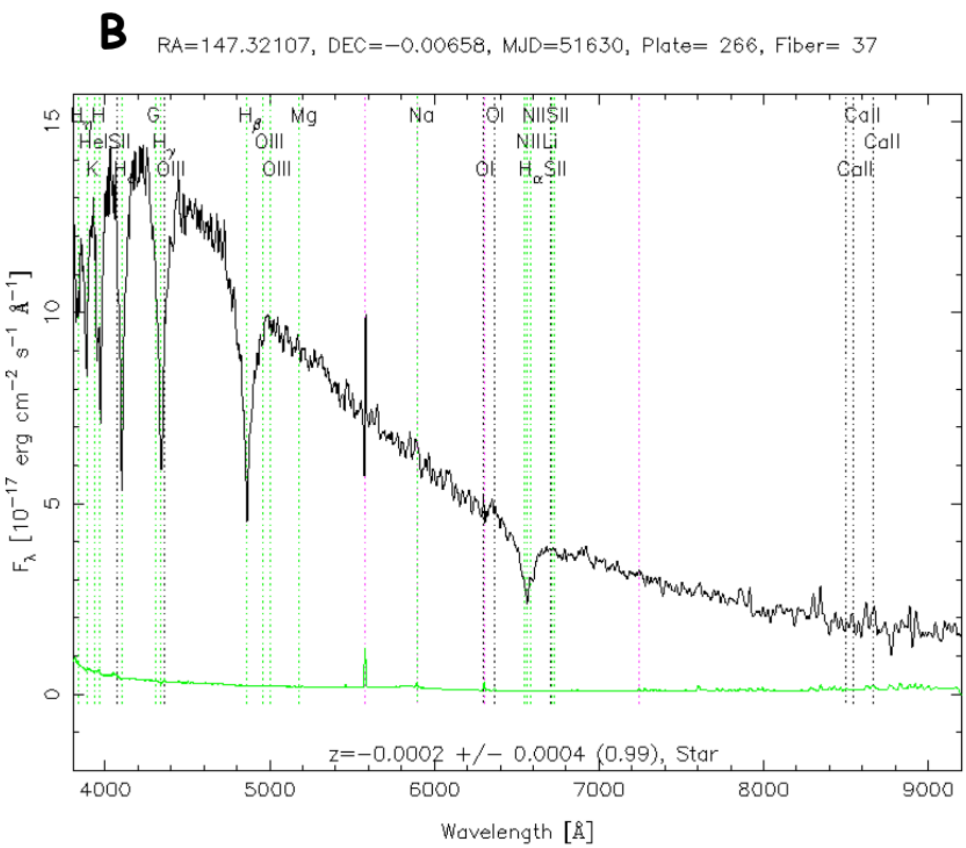
5. **Absorption Line Strength:** Consider two stars with similar temperatures, but Star A has stronger absorption lines for sodium than Star B. What could explain the difference in the strength of these lines? (The image below is included to remind you what absorption lines; a stronger absorption line would reflect a deeper dip in the intensity.)



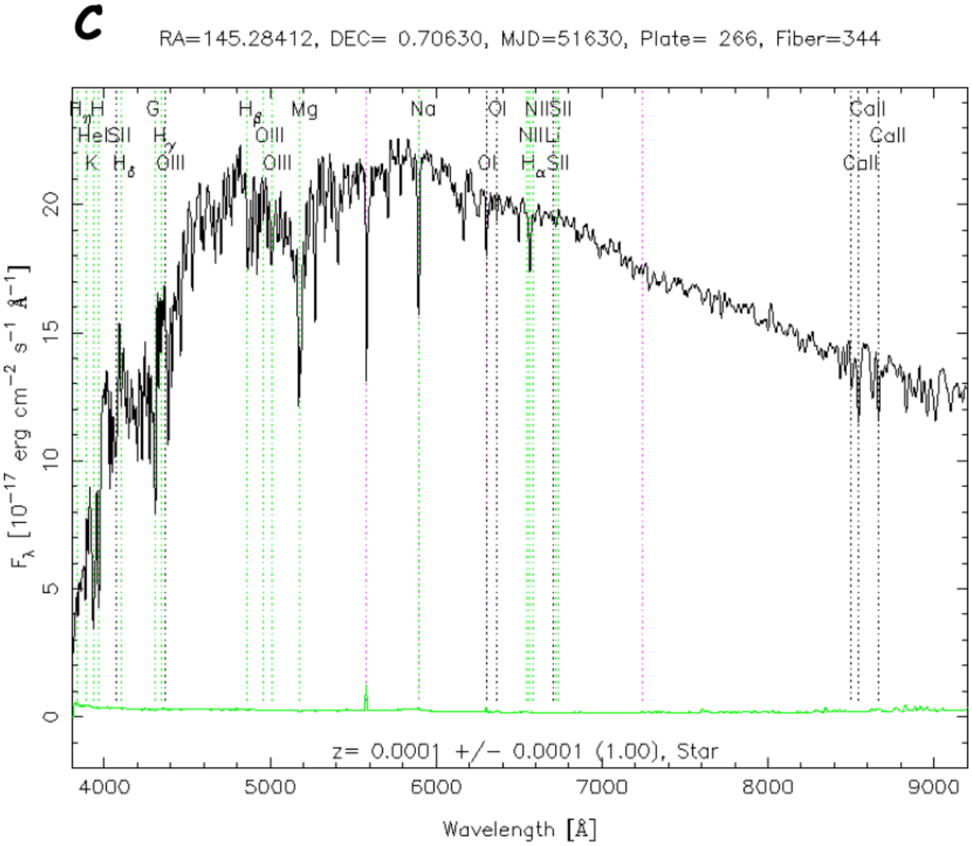
6. **Metallicity and Star Formation:** If a star has a high abundance of heavy elements (metals), what can this tell you about the star's generation? How does this information relate to the star's formation history?

Data: Stellar Spectra A–J

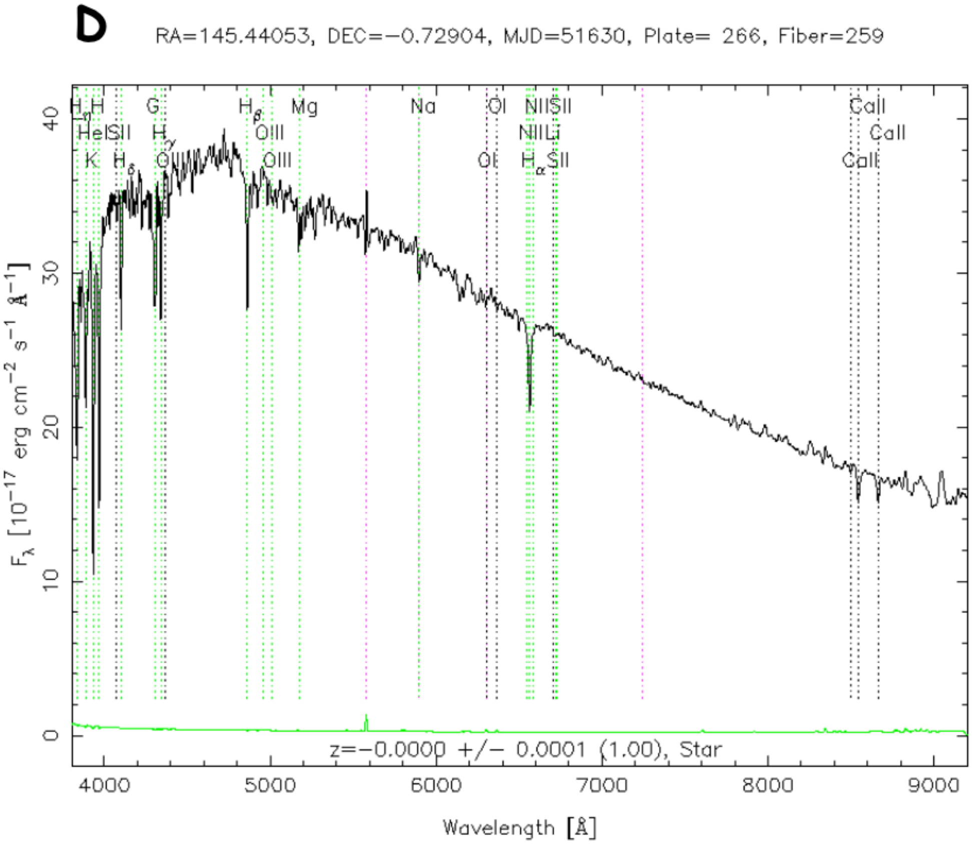




C


RA=145.28412, DEC= 0.70630, MJD=51630, Plate= 266, Fiber=344
F_λ [10^{-17} erg cm^{-2} s^{-1} Å^{-1}]
Wavelength [Å]
z= 0.0001 +/- 0.0001 (1.00), Star
Na
Mg
CaII

D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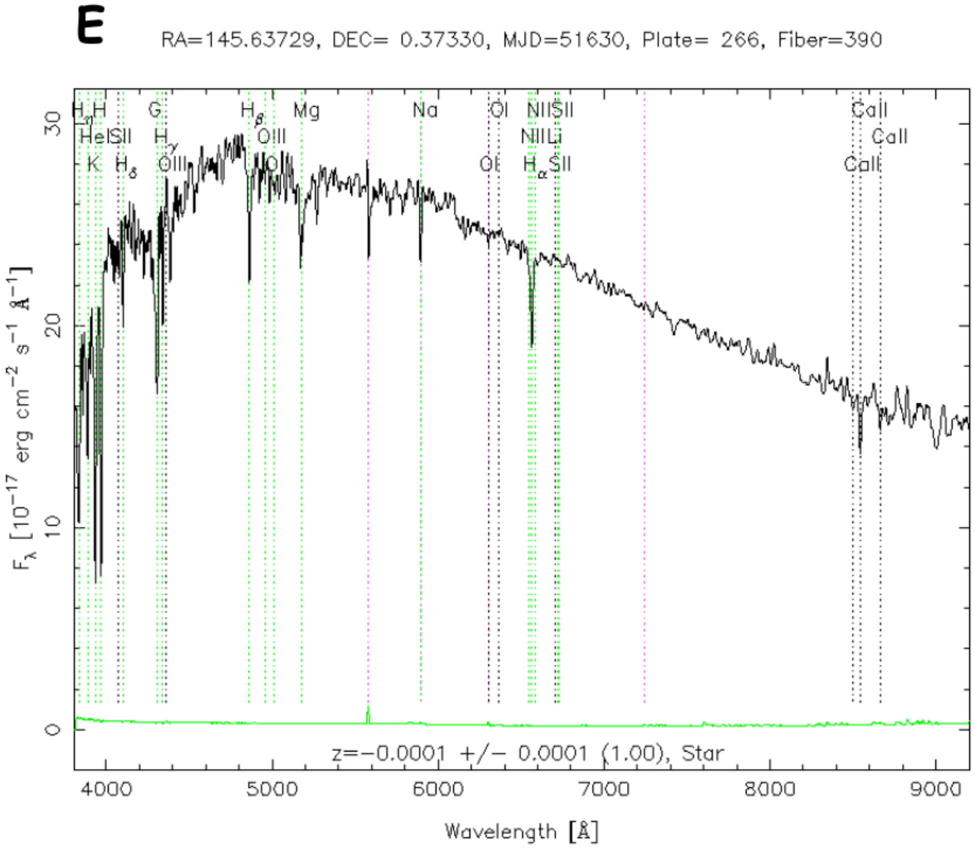
F_λ [10^{-17} erg cm^{-2} s^{-1} Å^{-1}]
Wavelength [Å]
z=−0.0000 +/− 0.0001 (1.00), Star
Na
Mg
CaII

E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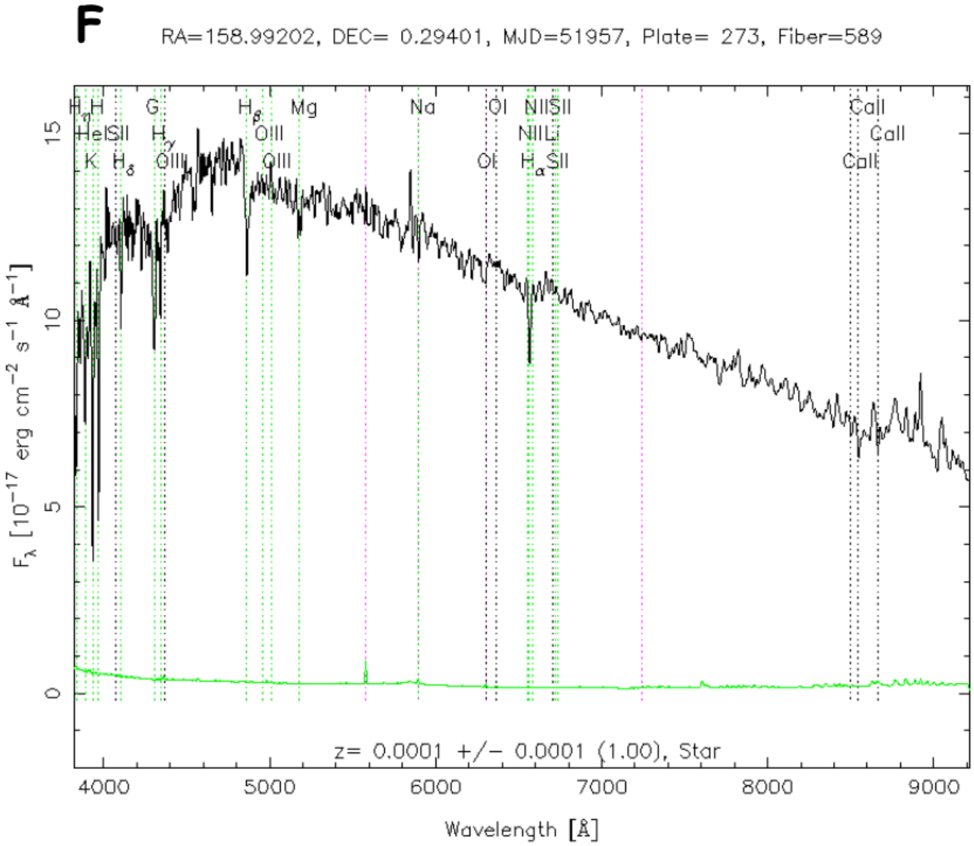
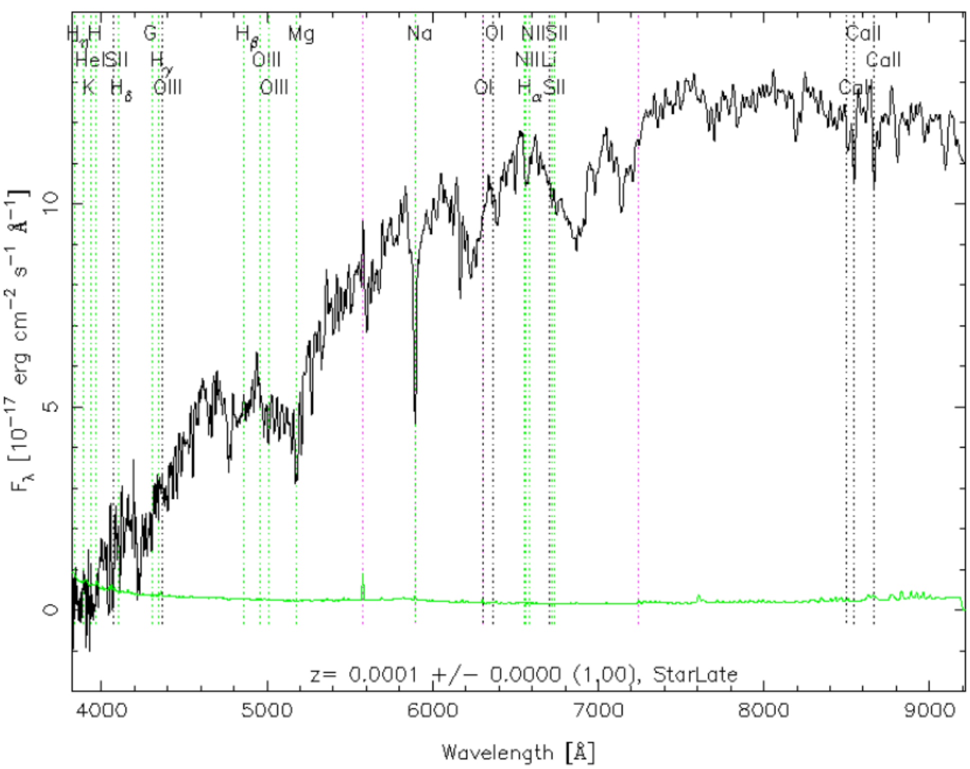
Wavelength [Å]
F_λ [10^-17 erg cm^-2 s^-1 Å^-1]

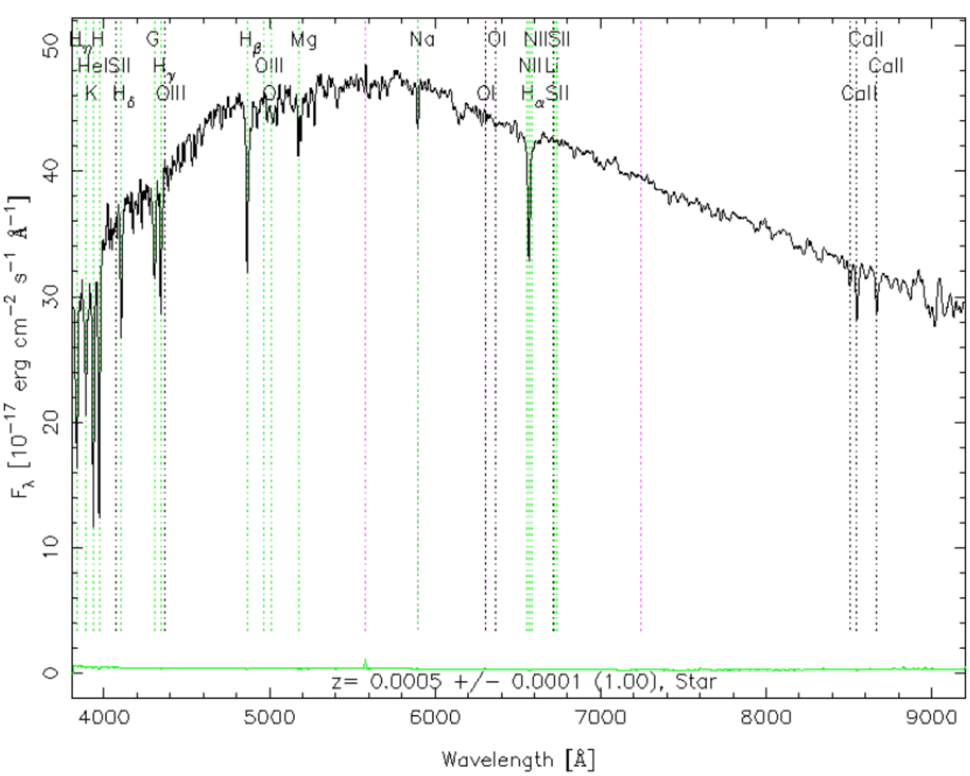
F


RA=158.99202, DEC= 0.29401, MJD=51957, Plate= 273, Fiber=589
z= 0.0001 +/- 0.0001 (1.00), Star
Wavelength [Å]
F_λ [10^-17 erg cm^-2 s^-1 Å^-1]

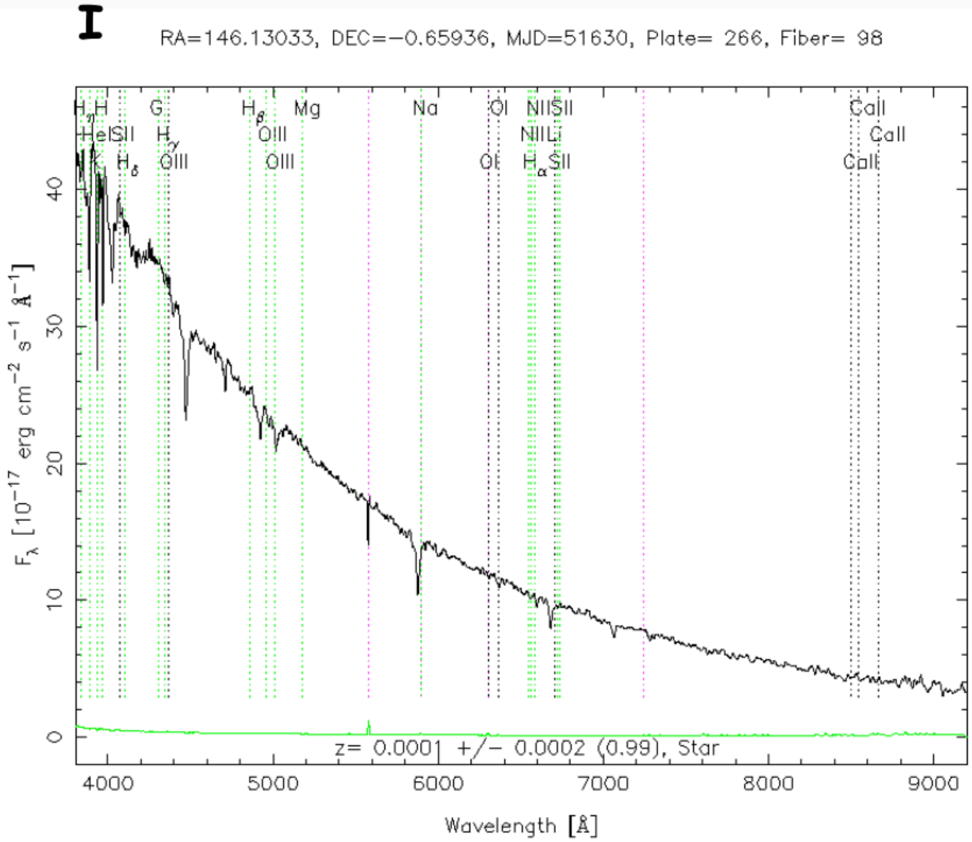
G RA=157.22871, DEC=−0.93284, MJD=51957, Plate= 273, Fiber=245



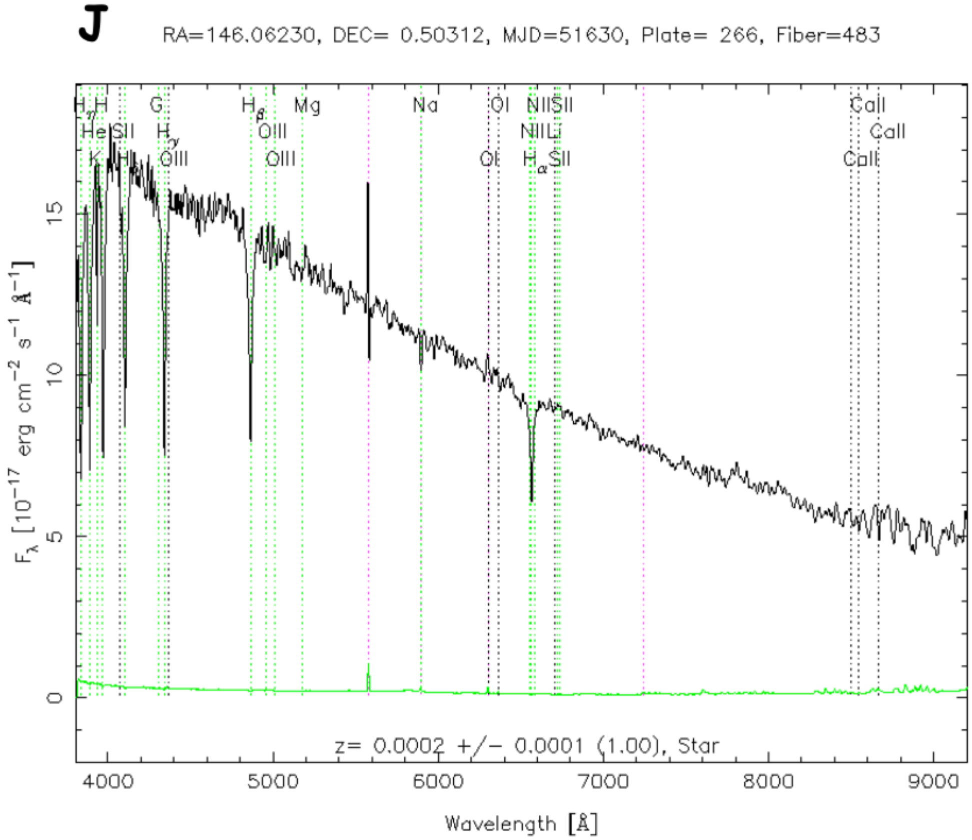
H RA=146.49713, DEC= 0.74242, MJD=51630, Plate= 266, Fiber=539



I


RA=146.13033, DEC=-0.65936, MJD=51630, Plate= 266, Fiber= 98
z= 0.0001 +/- 0.0002 (0.99), Star
Wavelength [Å]
F_λ [10^-17 erg cm^-2 s^-1 Å^-1]

J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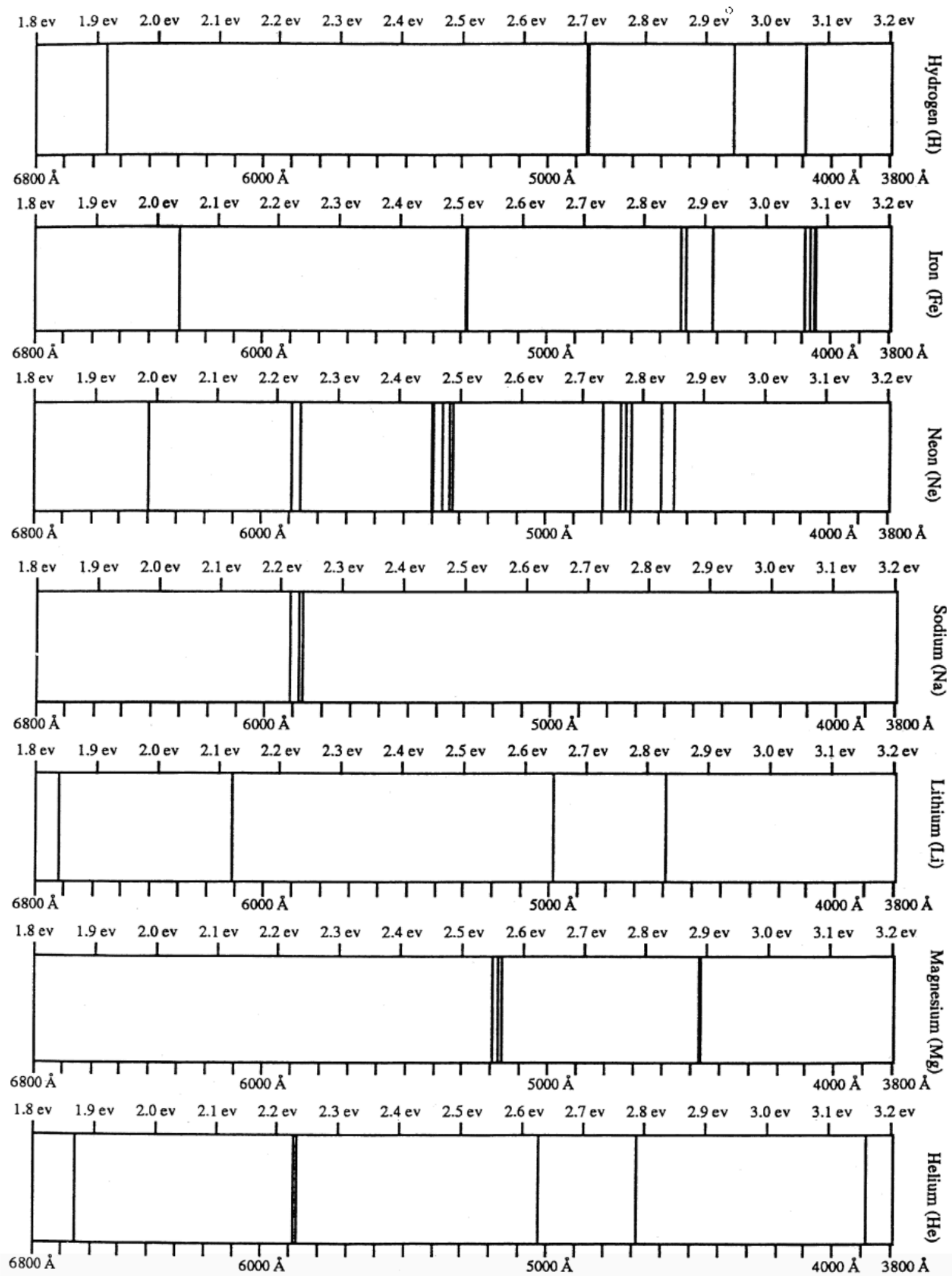
Wavelength [Å]
F_λ [10^-17 erg cm^-2 s^-1 Å^-1]

Data: Element Emission Line



Data: Stellar Absorption Lines