

Project_03_Measuring_Iron_Abundance

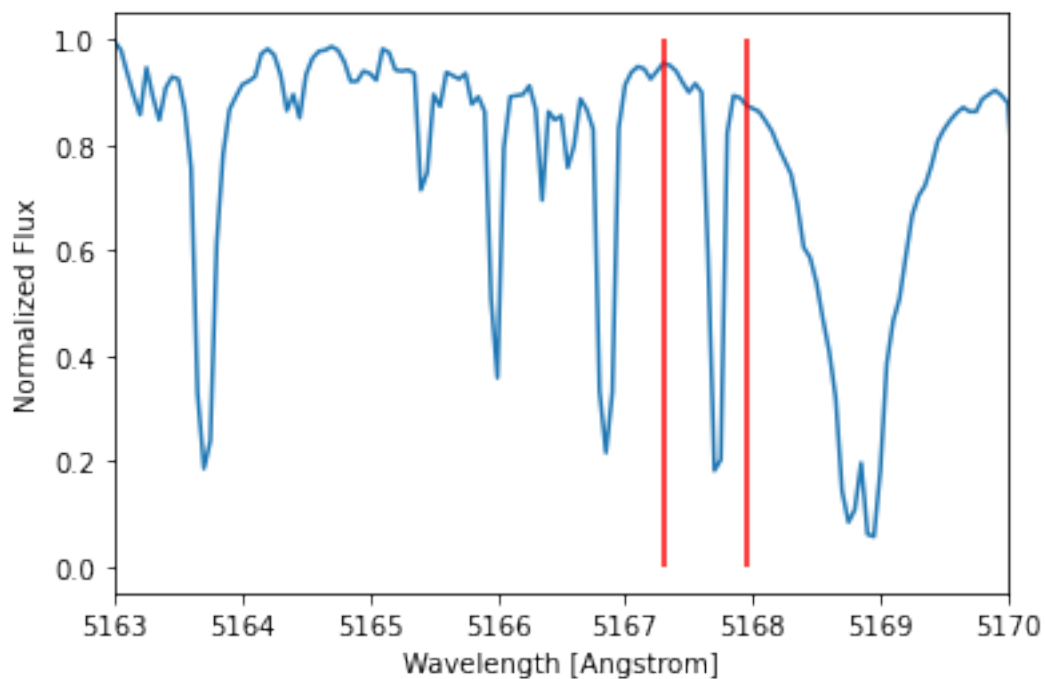
March 30, 2022

```
[15]: import numpy as np  
import matplotlib.pyplot as plt  
import astropy.io.ascii
```

```
[16]: spec = astropy.io.ascii.read("Mg5168.txt")
```

```
[17]: plt.plot(spec["col1"], spec["col2"])  
plt.vlines(5167.3, 0, 1, color="red")  
plt.vlines(5167.95, 0, 1, color="red")  
plt.xlim(5163, 5170)  
plt.xlabel("Wavelength [Angstrom]")  
plt.ylabel("Normalized Flux")
```

```
[17]: Text(0, 0.5, 'Normalized Flux')
```



```
[18]: # This is the FeI emission for 5166.3 according to the solar survey archive
# All of the values in his file seem slightly shifted to the right
```

```
#Picked width values
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wval1 = 5167.3
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```
wval2 = 5167.95
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```
[19]: ind = np.where((spec["col1"] < wval2) & (spec["col1"] > wval1))
inc = np.median(np.diff(spec["col1"][ind]))
ew = np.sum(1 - spec["col2"][ind]) * inc
print("Equivalent width (ew) = ", ew, " Angstrom")
```

Equivalent width (ew) = 0.15267944786179077 Angstrom

```
[20]: # Log value with the ew divided by the wavelength of the line
np.log10(0.1526 / 5166.3)
```

```
[20]: -4.529625087839355
```

```
[21]: #With a log on the y-axis of -4.52, we get a value on the x-axis approximately
↪13.5
```

```
# According to the solar survey Archive, the oscillator strength is
```

```
f = 0.00000709
```

```
N = 10**13.4 / f / (5166.3 / 5000)
```

```
# N = 3.43 * 10^18
```

```
N1 = 3.43*10**18
```

Site for transmission

0.0.1 1. Ratio of ground state to excited state Fe atoms $\frac{N_2}{N_1} = \frac{g_2}{g_1} \exp\left(-\frac{E_2-E_1}{kT}\right)$

```
[22]: # The transition for this line is a 4p to 4s
```

```
# Constants
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h = 6.626 * 10 ** (-34)
```

```
c = 3 * 10 ** 8
```

```
k = 1.38 * 10 ** (-23)
```

```
T = 5770
```

```
# Calculation
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```
N2_N1 = 3 * np.exp(- h * c / 5166.3 * 10 ** 10 / (k * T)) ## Boltzmann Equation
```

```
print('Ratio of Fe atoms in excited to ground state:', N2_N1)
```

Ratio of Fe atoms in excited to ground state: 0.02390870247135607

```
[23]: # Number density of neutral Fe atoms

Neutral_N = N2_N1 * N1 + N1

print('Number density of neutral Fe atoms:', Neutral_N)
```

Number density of neutral Fe atoms: 3.5120068494767514e+18

0.1 2. Ratio of neutral to ionized Fe atoms $\frac{N_{aII}}{N_{aI}} = \frac{2kT}{P_e} \frac{Z_{II}}{Z_I} \left(\frac{2\pi m_e kT}{h^2} \right)^{3/2} \exp\left(-\frac{\chi}{kT}\right),$

```
[24]: # Ionization energy for Fe is 7.9024
# Constants

# Have not been able to find the partition function values for Fe
# (assuming they are different) so plugging in the given Z values
ZI = 2.4
ZII = 1
Me = 9.1 * 10 ** (-31)
# Ionization energy for Fe is 7.9024
Chi = 7.9024

# Calculation
FeII_FeI = 2 * k * T * 1 / (2.4) * ((2 * np.pi * Me * k * T
                                     / (h) ** 2)) ** (3/2) * np.exp(-
    ↳ Chi * 1.6 * 10 ** (-19) / (k * T)) ## Saha Equation
print('Ionized to Neutral Fe ratio:', FeII_FeI)
```

Ionized to Neutral Fe ratio: 8.899314274298392

```
[25]: # Number density of Ionized Fe

Ion_N = FeII_FeI * Neutral_N

print('Number density of Ionized Fe:', Ion_N)
```

Number density of Ionized Fe: 3.125445268698218e+19

0.2 3. Total column density of Fe atoms $N_1 \times \left(1 + \frac{N_2}{N_1}\right) \times \left(1 + \frac{N_{aII}}{N_{aI}}\right)$

```
[26]: #Total number
N_tot = N1 * (1 + N2_N1) * (1 + FeII_FeI)
print('Total Fe atoms:', N_tot)
```

Total Fe atoms: 3.4766459536458932e+19

0.3 4. Fe abundance relative to hydrogen

```
[27]: #Finding the Fe abundance in the sun relative to Hydrogen
ratio_part = N_tot / (6.6 * 10 ** 23)
Fe_ab = 12 + np.log10(ratio_part)
print('Fe Abundance:', Fe_ab)
print('Official value for Sun:', 7.5)
```

Fe Abundance: 7.721616530750593
Official value for Sun: 7.5

```
[32]: # Mole ratio between Fe and H is ratio_part

print('Mole ratio between Fe and H:', ratio_part)

# Astronomer working on stars value [Fe/H]

# [Fe/H] = log(calculated mole ratio / actual mole ratio)

ratio_ph_sun = 10**(7.5 - 12)

Fe_H = np.log10(ratio_part / ratio_ph_sun)

print(' [Fe/H]:', Fe_H)
```

Mole ratio between Fe and H: 5.26764538431196e-05
[Fe/H]: 0.22161653075059265

However, [Fe/H] should be zero, since the calculated ratio should be the same as the actual ratio.

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[ ]:
```