Project_03_Measuring_Iron_Abundance

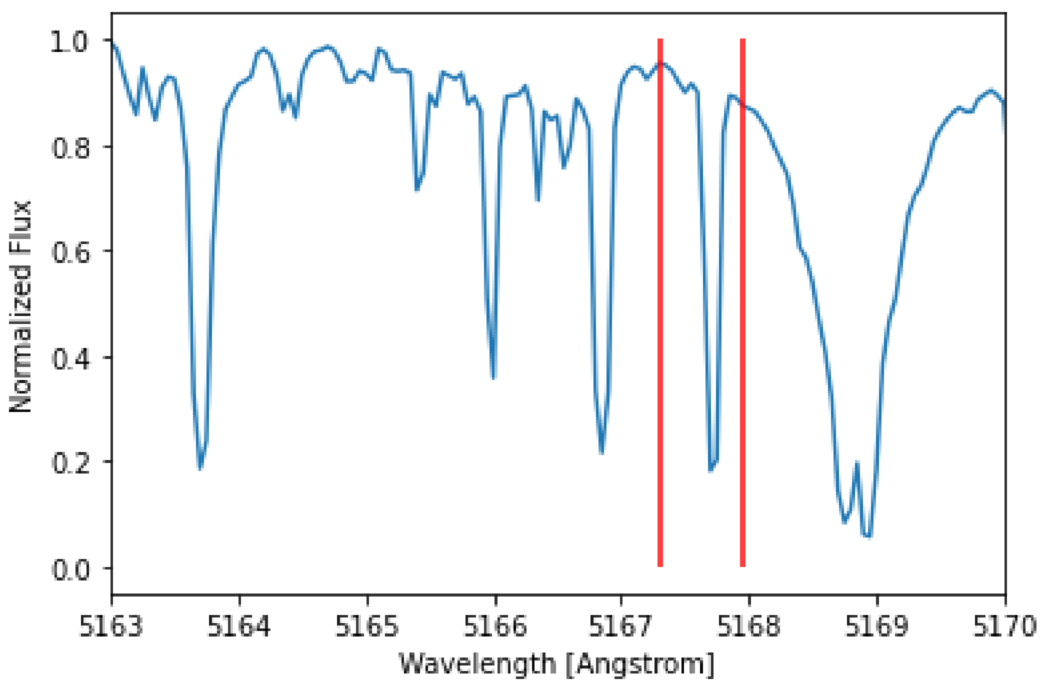
March 24, 2022

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

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

[17]:
```python
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
wval1 = 5167.3
wval2 = 5167.95
```

[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
h = 6.626 * 10 ** (-34)
c = 3 * 10 ** 8
k = 1.38 * 10 ** (-23)
T = 5770

# Calculation

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 $\frac{Na_{II}}{Na_I} = \frac{2kT}{P_e}\frac{Z_{II}}{Z_I}\left(\frac{2\pi m_e kT}{h^2}\right)^{3/2}\exp\left(-\frac{\chi}{kT}\right)$,

[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 $N_1 \times (1 + \frac{N_2}{N_1}) \times (1 + \frac{Na_{II}}{Na_I})$

[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
```

[28]:
```
# Other ways of describing this relative abundance

# At least according to the example notebook

ratio_ph_sun = 10**(7.5 - 12)

print(np.log10(ratio_part / ratio_ph_sun))

print((ratio_ph_sun - ratio_part)/ ratio_ph_sun * 100)
```

```
0.22161653075059265
-66.57757320498787
```

[ ]:
```
```