A Comprehensive Study of Double-Lined Binary White Dwarfs

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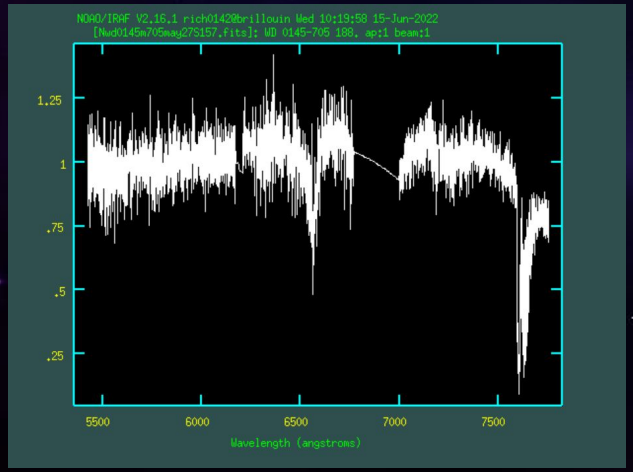
Outline

- Data reduction
- Barycentric velocity corrections
- Statistical analysis
  - Chi Squared
  - P values
- Target Results
  - 7 targets analyzed

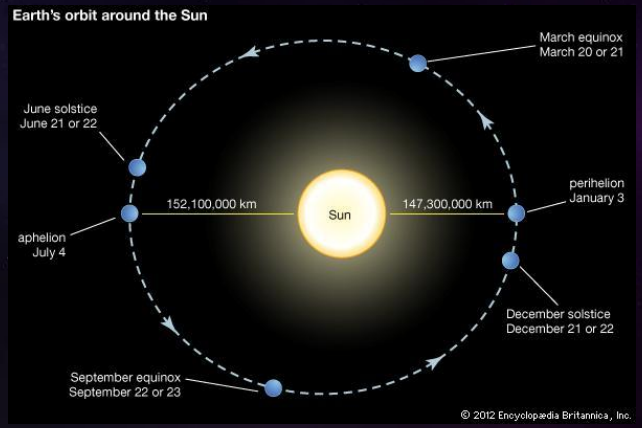
Data Analysis

- Converting raw data into a readable graph using IRAF (Image Reduction and Analysis Facility)
- Use the package continuum



Barycentric Velocity Correction

- The calculated velocity is not completely accurate
  - Must account for Earth's orbit around the Sun
  - IRAF package xcsao




```
wd1017m138apr20S118.fits Object: WD1017-138
RA: 10:19:52.36 Dec: -14:07:34.3 2000.0
2022-Apr-20 03:05:36.23 =HJD2459689.6325 BCV: -19.99
6400.0A- 6700.0A 2048 points, filter: 5 20 125 250 apodize 0.05 fit 0.5 best 1
Temp:         temp1129 vel:   0.00  tsh:   0.00 HCV:  14.38 Peak:  55.072 h:0.299 R:   4.24 CZ:  20.705 +/-  15.238 1
```

```
wd1017m138apr25S038.fits Object: WD1017-138
RA: 10:19:52.36 Dec: -14:07:34.3 2000.0
2022-Apr-25 01:52:55.85 =HJD2459694.5817 BCV: -21.40
6400.0A- 6700.0A 2048 points, filter: 5 20 125 250 apodize 0.05 fit 0.5 best 1
Temp:         temp1129 vel:   0.00  tsh:   0.00 HCV:  14.38 Peak:  65.175 h:0.434 R:   5.86 CZ:  29.389 +/-   8.626 1
```

Weighted Mean Velocity

- These systems have varying velocities with varying errors
    - The weighted mean velocity gives greater importance to values with lower error
- Is a more accurate representation of the average velocity of the system
- Useful for the following calculations

Chi Squared

- Shows how statistically significant different values are to one another
    - Compares what we observe to what we expect

$$\chi^2 = \Sigma [(\text{Observed Velocity} - \text{WM Velocity})/\text{Observed Error}]^2$$

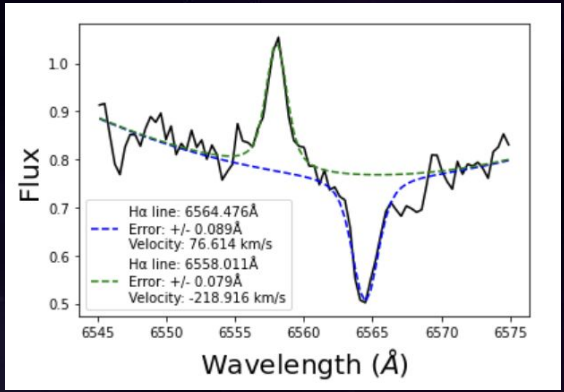
P-Values

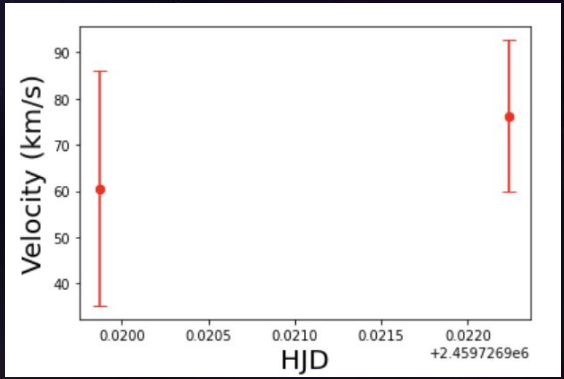
- Null Hypothesis: there is no significant difference between the observed and expected frequencies
- Perform a χ^2 test to either confirm or reject the hypothesis

```
from scipy.stats import chi2
p_value = chi2.sf(chi squared,degrees of freedom)
print(p_value)
```

- Log (p) < -4 can be considered a binary system

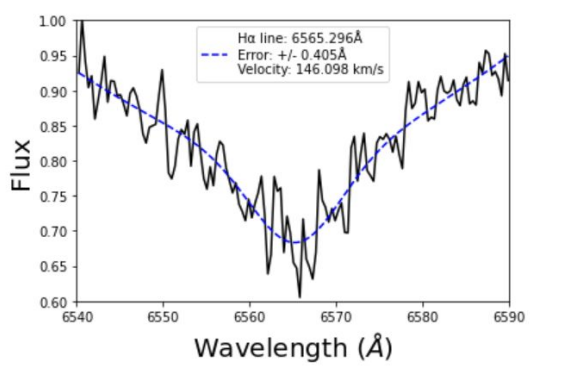
WD0145-705

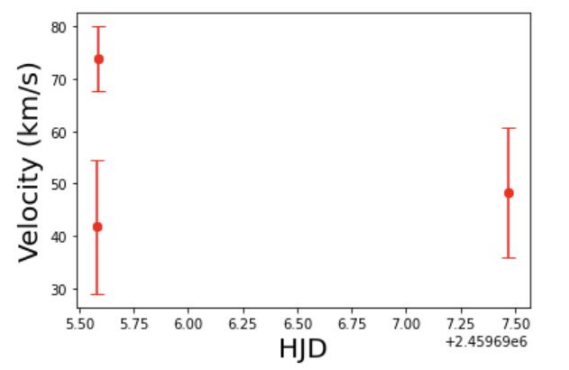




- Average Absorption Wavelength = 6564.055 +/- 0.458 Å
- WM Velocity = 71.643 +/- 13.786 km/s
- χ^2 = 0.269
- Degrees of Freedom = 1
- Log (p) = -0.219

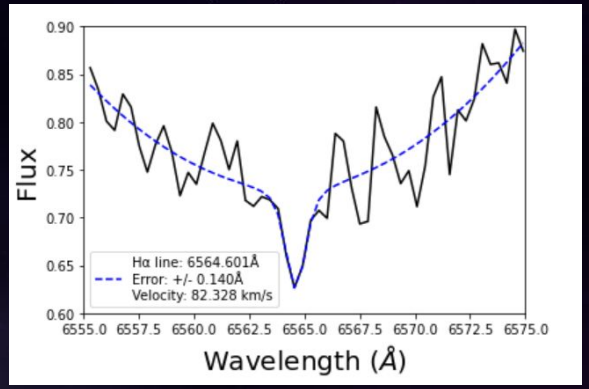
WD0927-173

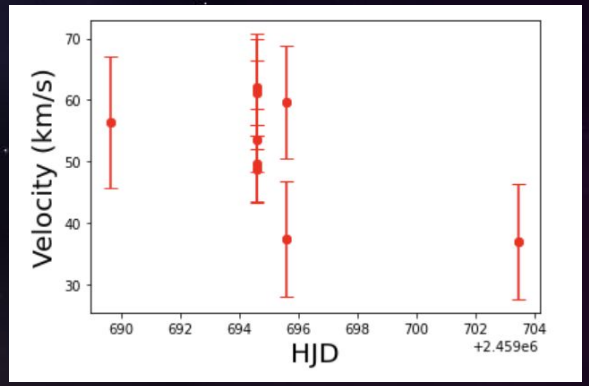




- Average Absorption Wavelength = 6564.498 +/- 0.228 Å
- WM Velocity = 64.603 +/- 5.047 km/s
- χ^2 = 7.208
- Degrees of Freedom = 2
- Log (p) = -1.57

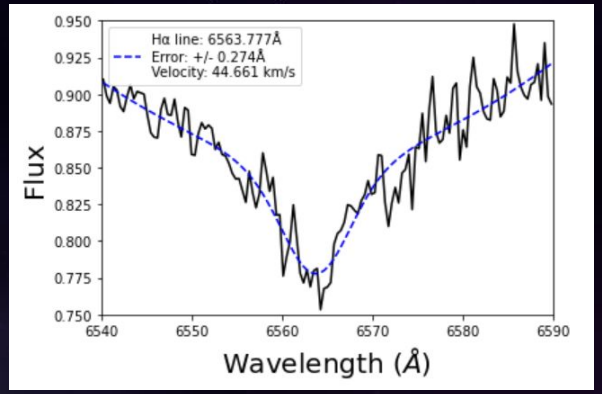
WD1017-138

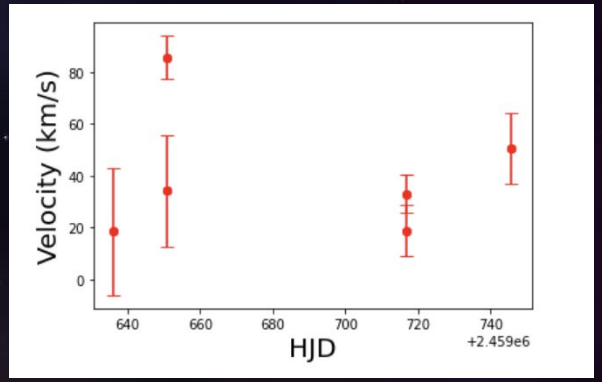




- Average Absorption Wavelength = 6564.424 +/- 0.170 Å
- WM Velocity = 53.425 +/- 2.195 km/s
- χ^2 = 11.810
- Degrees of Freedom = 9
- Log (p) = -0.65

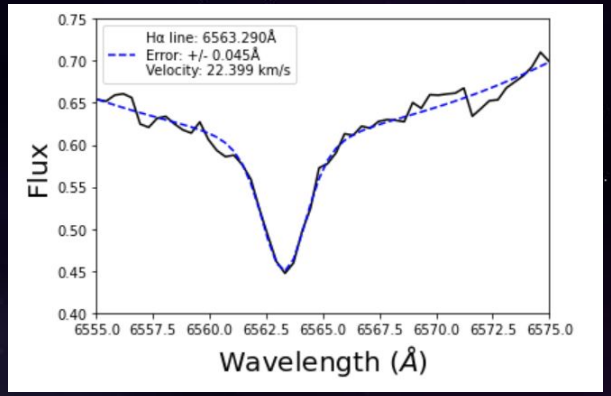
WD1109+244

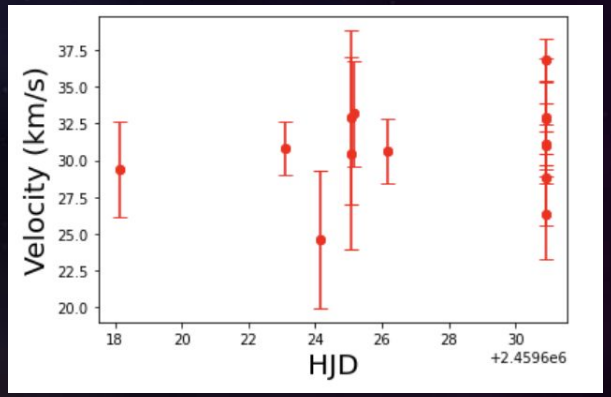




- Average Absorption Wavelength = 6564.009 +/- 0.331 Å
- WM Velocity = 46.259 +/- 4.374 km/s
- χ^2 = 35.243
- Degrees of Freedom = 5
- Log (p) = -5.87

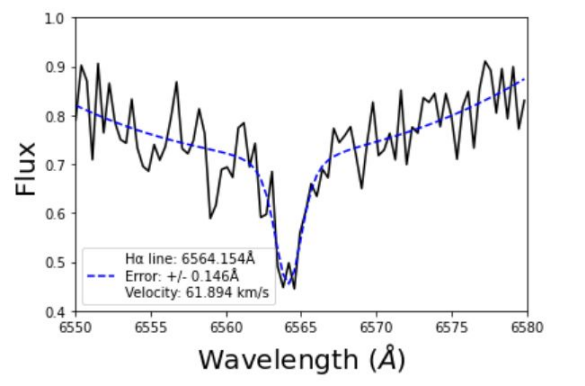
WD1129+155

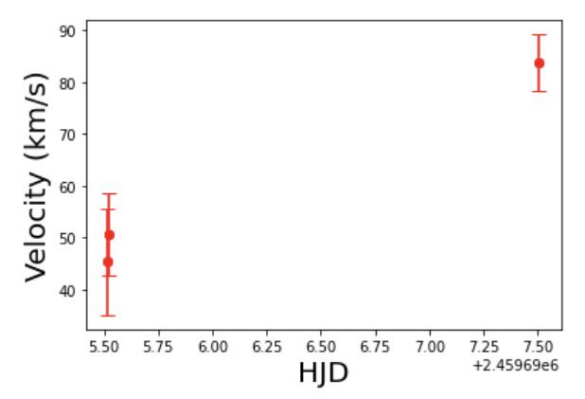




- Average Absorption Wavelength = 6563.250 +/- 0.072 Å
- WM Velocity = 31.919 +/- 0.657 km/s
- χ^2 = 20.126
- Degrees of Freedom = 13
- Log (p) = -1.04

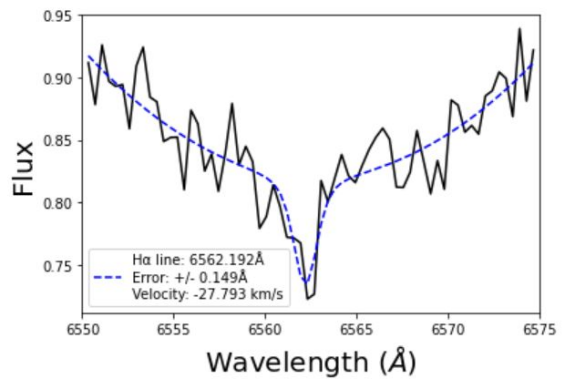
WD1152-287

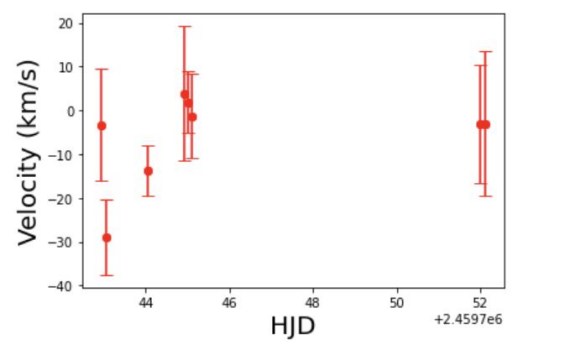




- Average Absorption Wavelength = 6564.341 +/- 0.172 Å
- WM Velocity = 68.825 +/- 4.083 km/s
- χ^2 = 18.245
- Degrees of Freedom = 2
- Log (p) = -3.96

WD2120+054





- Average Absorption Wavelength = 6562.140 +/- 0.224 Å
- WM Velocity = -8.578 +/- 3.260 km/s
- χ^2 = 10.233
- Degrees of Freedom = 7
- Log (p) = -0.75

Moving Forward

- While none of these 7 targets seem to show clear double-line features, a few of them are still white dwarf binaries and show other interesting features
- The last of our observations will be finished by the end of July
    - Perhaps these new data sets will provide useful information
- The parameters of these systems still need to be constrained

Questions?