A Comprehensive Study of Double-Lined Binary White Dwarfs

Jillian Richardson
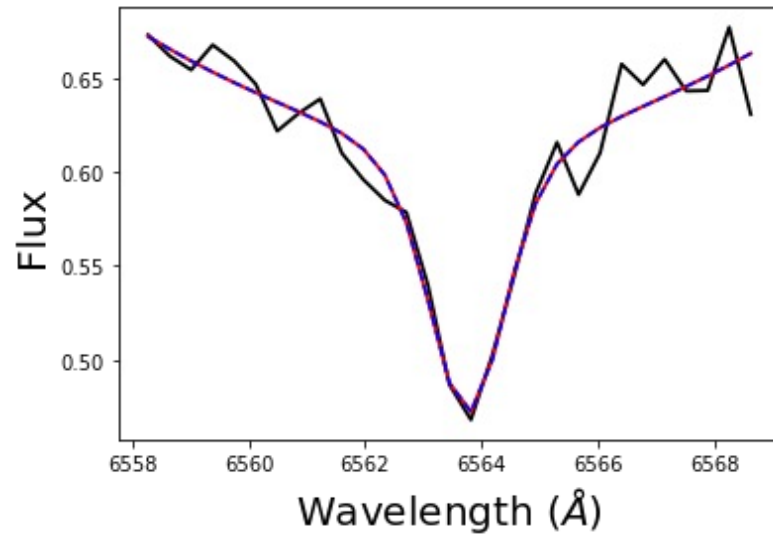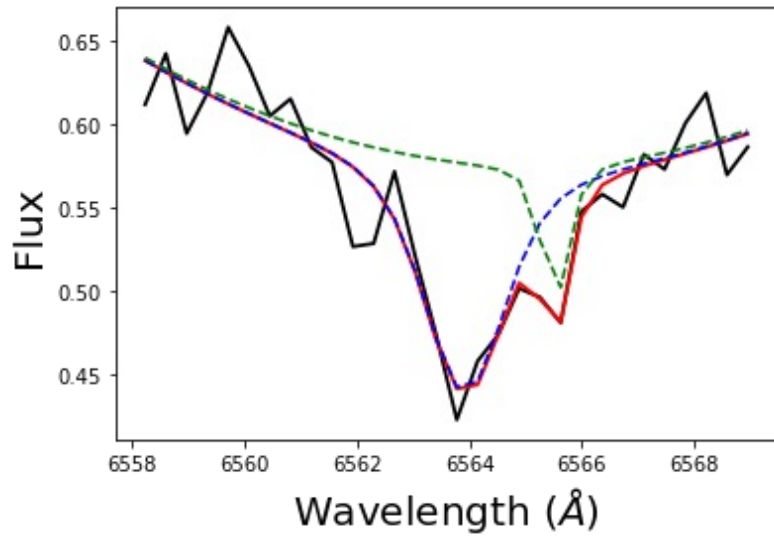
Mentor: Dr. Mukremin Kilic

Background

- White dwarfs are stellar core remnants supported by electron-degeneracy pressure

- Binary white dwarf systems will show variation in velocity as they orbit around each other

- We analyzed 13 targets to determine whether they are binary systems

Double-Lined vs Single-Lined

H-Alpha Line

- 6562.8 Angstrom
- Created by a hydrogen electron dropping energy levels
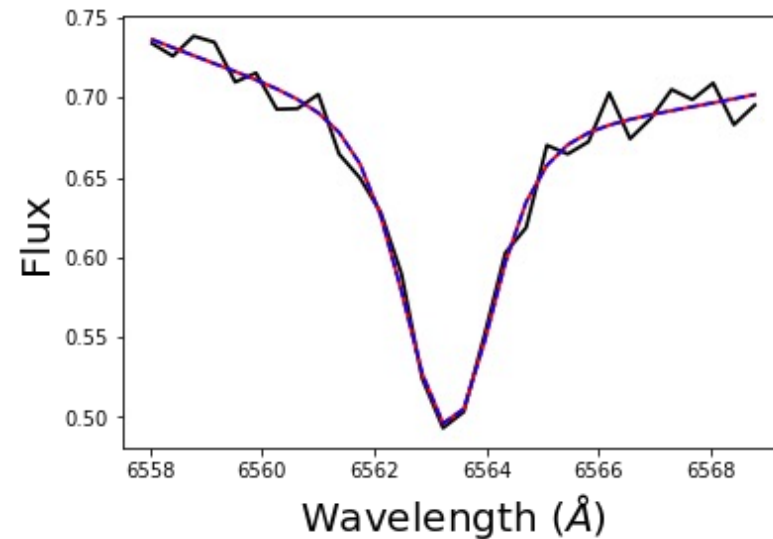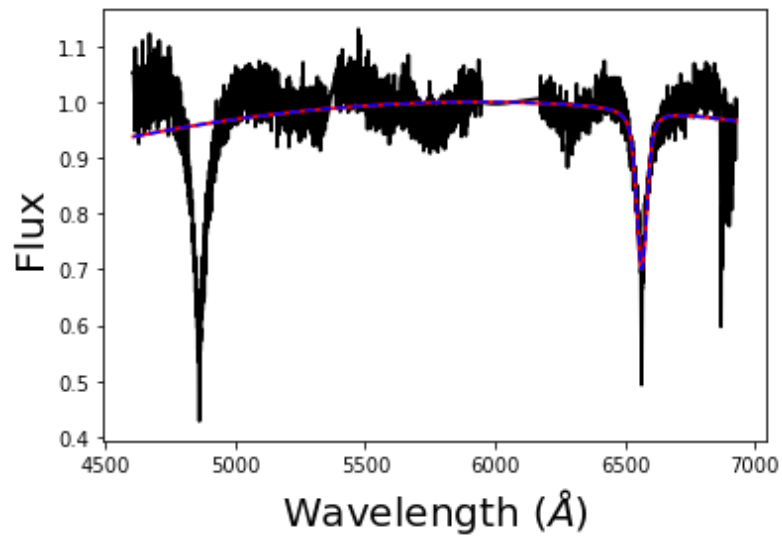
Doppler Effect

$$v = \frac{\Delta\lambda}{\lambda_0} \times c$$

$v \equiv$ line of sight velocity

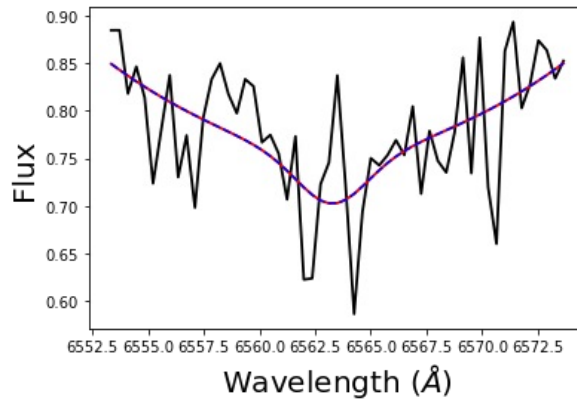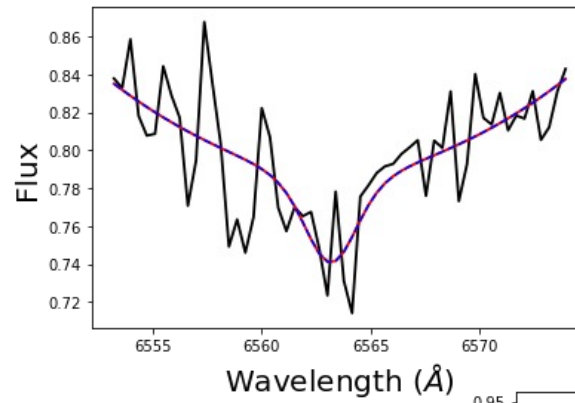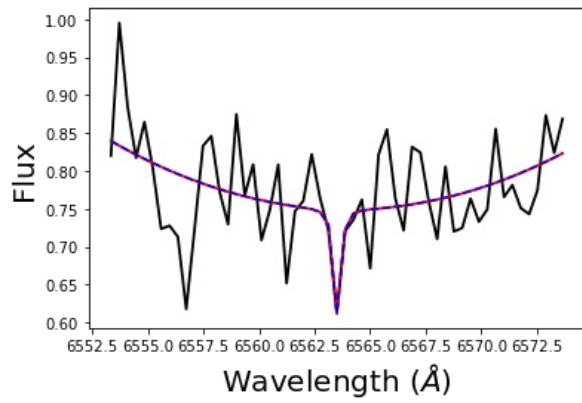$\lambda_0 \equiv$ rest wavelength

$\Delta\lambda \equiv$ measured wavelength – rest wavelength

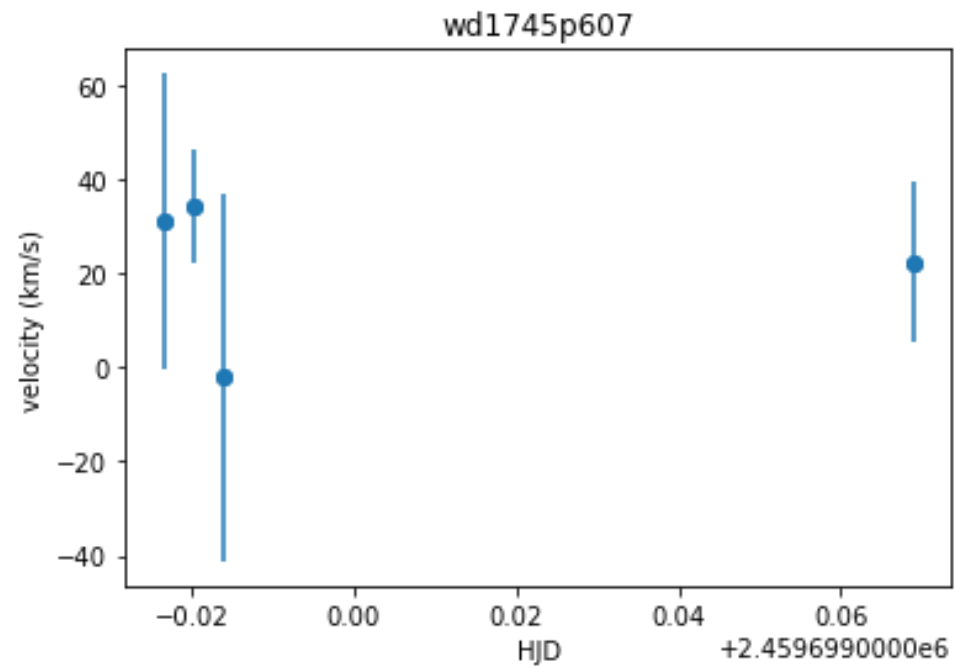$c \equiv$ speed of light

Bootstrapping

- Statistical method of measuring uncertainty
  - The data is sorted, and any duplicates are removed
  - Randomly selects data values (with replacement) 2000 times
  - The standard deviation is calculated for each time and the average of these gives the uncertainty

Wd1745p607
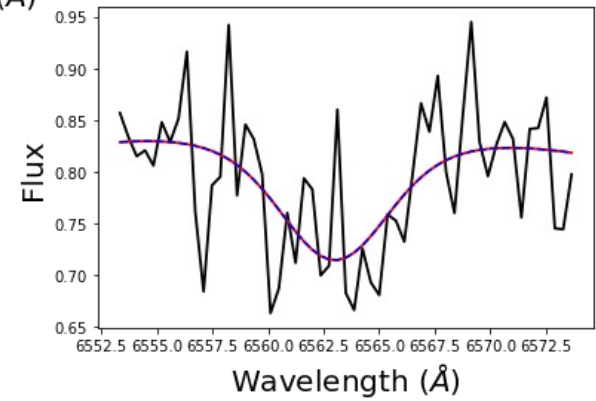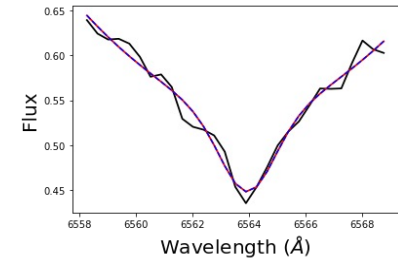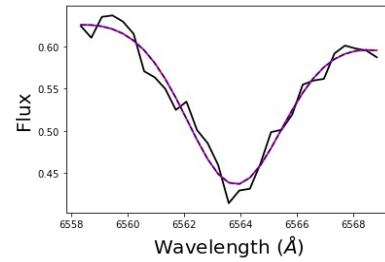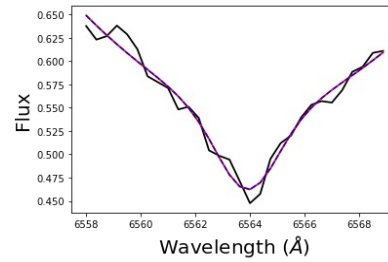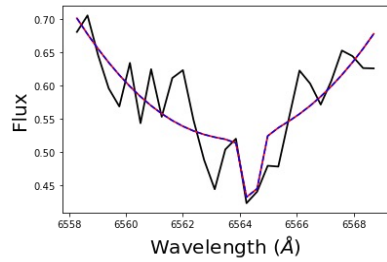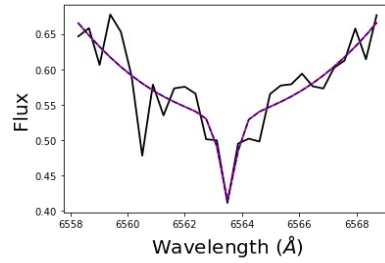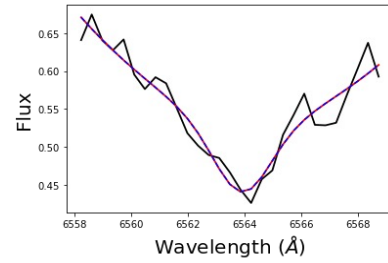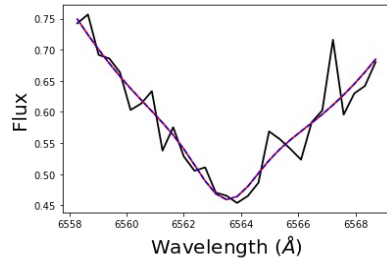
Wd1745p607 Time vs Velocity

Wd1745p607 Results
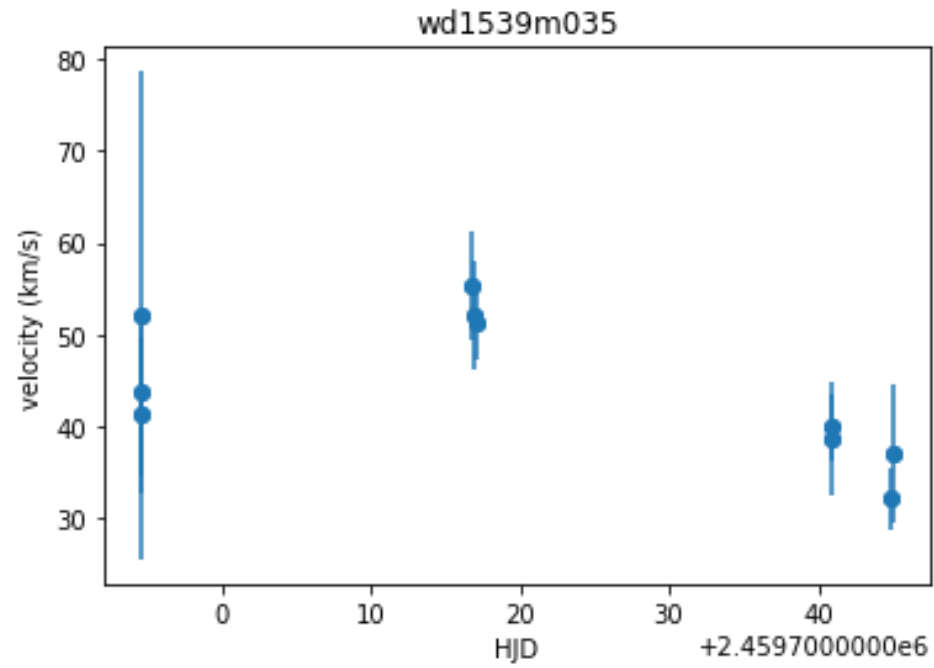
- To conclude a system is binary log(p-value) must be < -4
- Very high levels of noise and few measurements make it difficult to draw conclusions
- Need further measurements

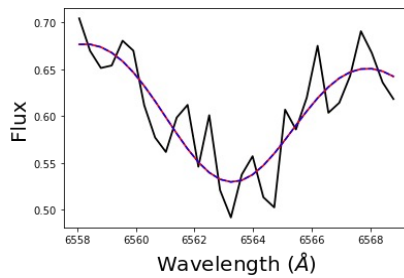| Weighted Mean Velocity (km/s)	χ^2	P-value	Log(p-value)
28.7+-9.2	0.98	0.81	-0.22

Wd1539m035
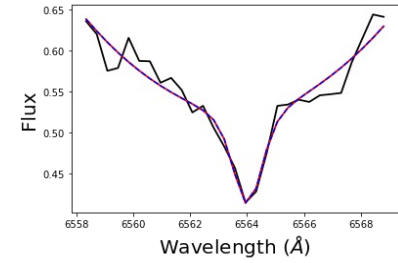
Wd1539m035 Time vs Velocity

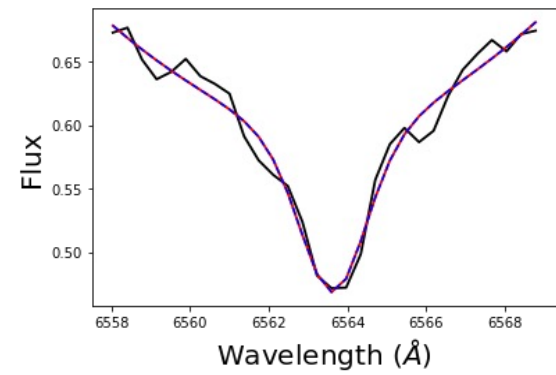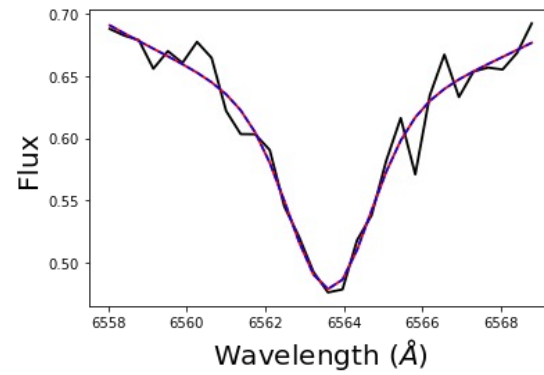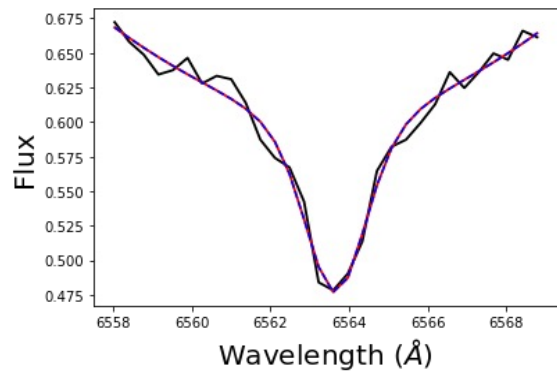# Wd1539m035 Results
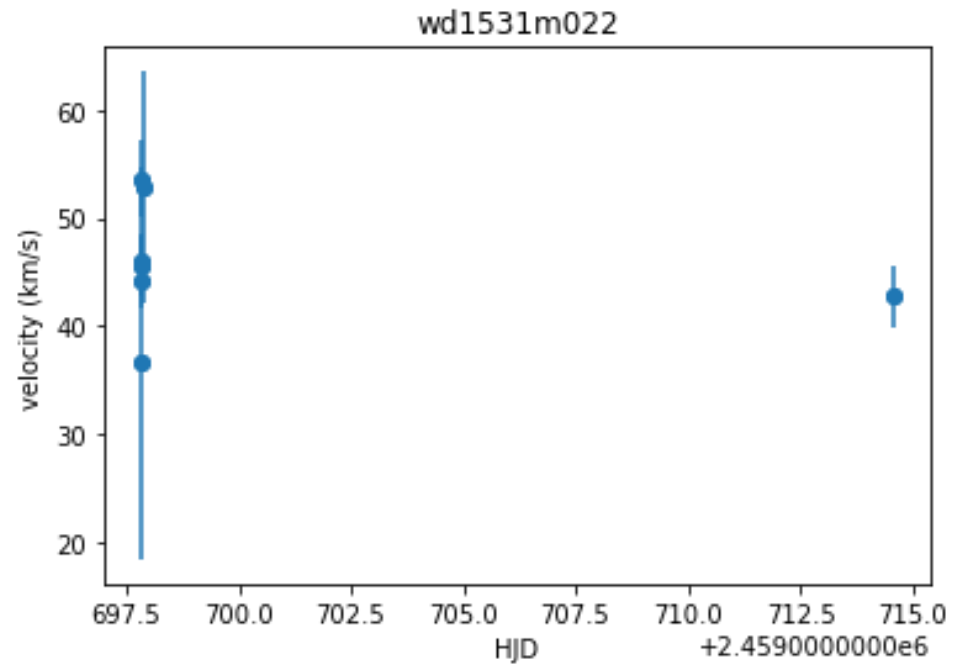
- Log(p-value) < -4 implies there is enough variation in velocity to conclude this is a binary system
- Single lined binary

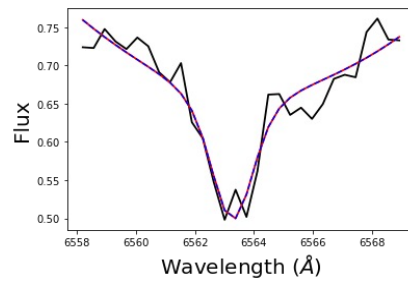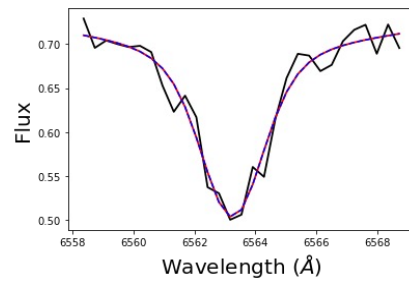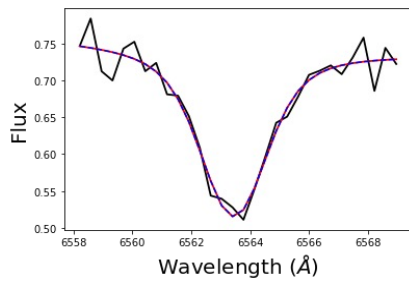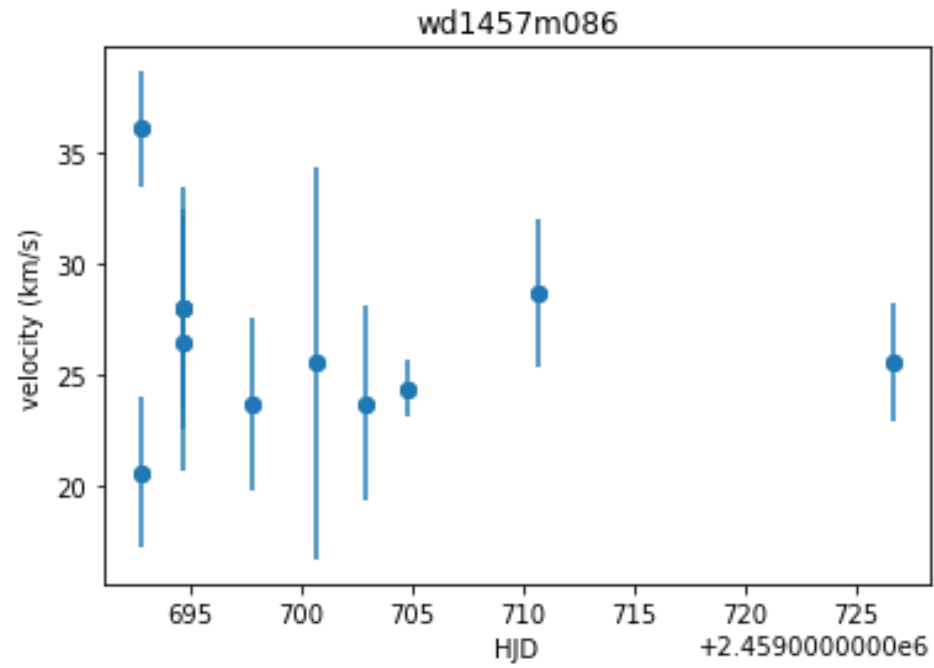| Weighted mean velocity (km/s)	χ^2	P-value	Log(p-value)
42.3+-1.7	25.6	0.007	-4.9

Wd1531m022
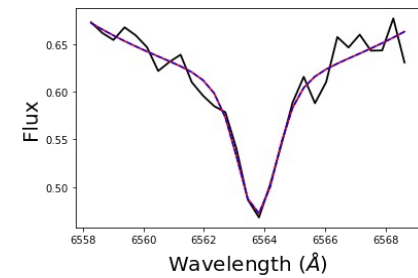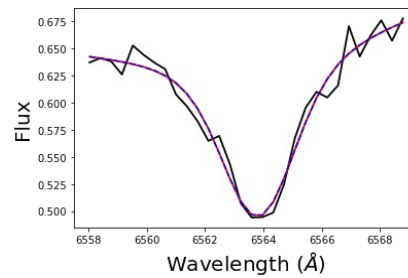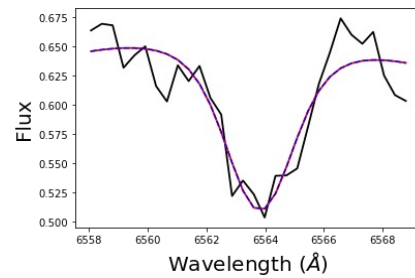
Wd1531m022 Time vs Velocity

Wd1531m022 Results

- Not enough velocity variation to conclude it's a binary system

Weighted mean velocity (km/s)	χ²	P-value	Log(p-value)
46.0+-1.2	0.2	0.99	-0.0002

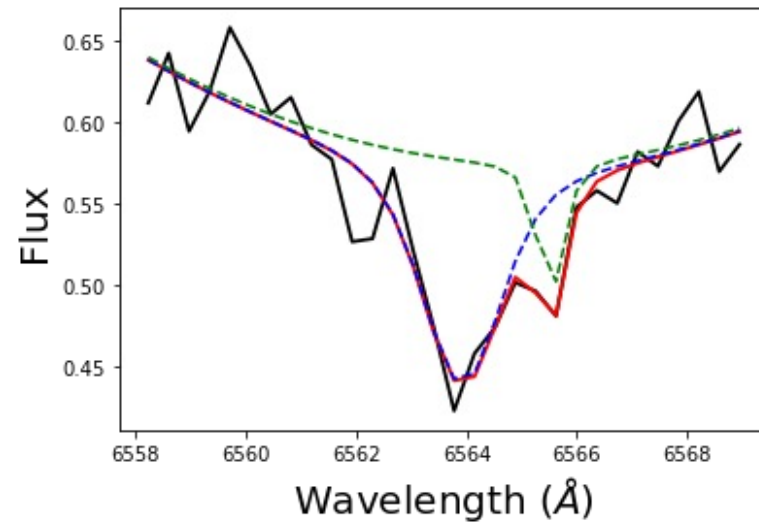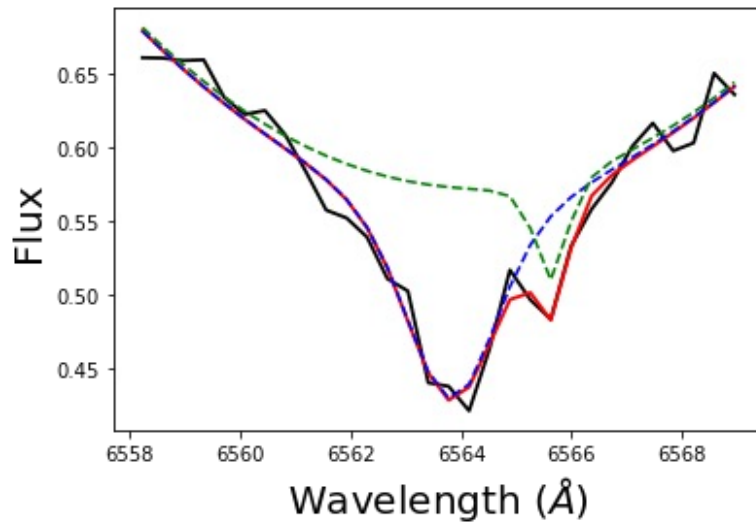# Wd1457m086
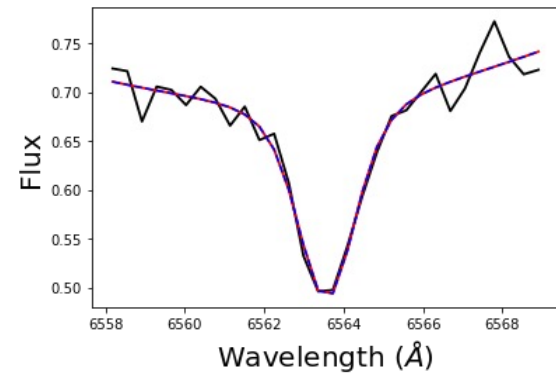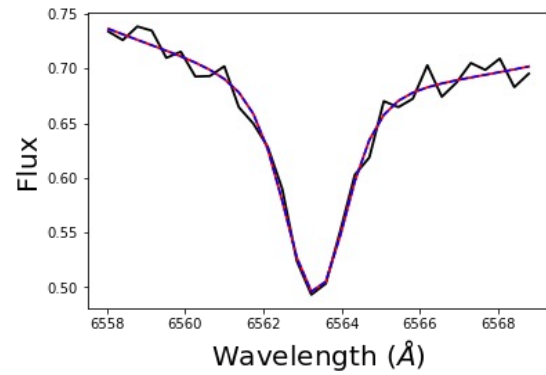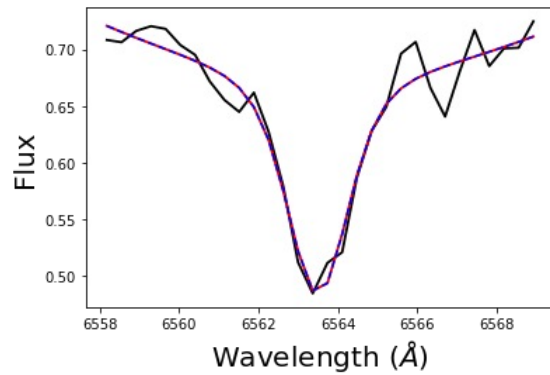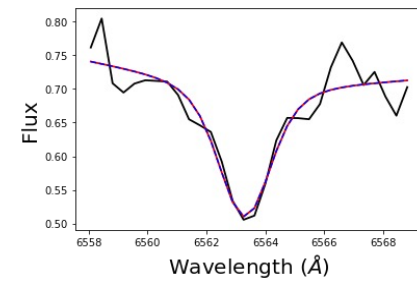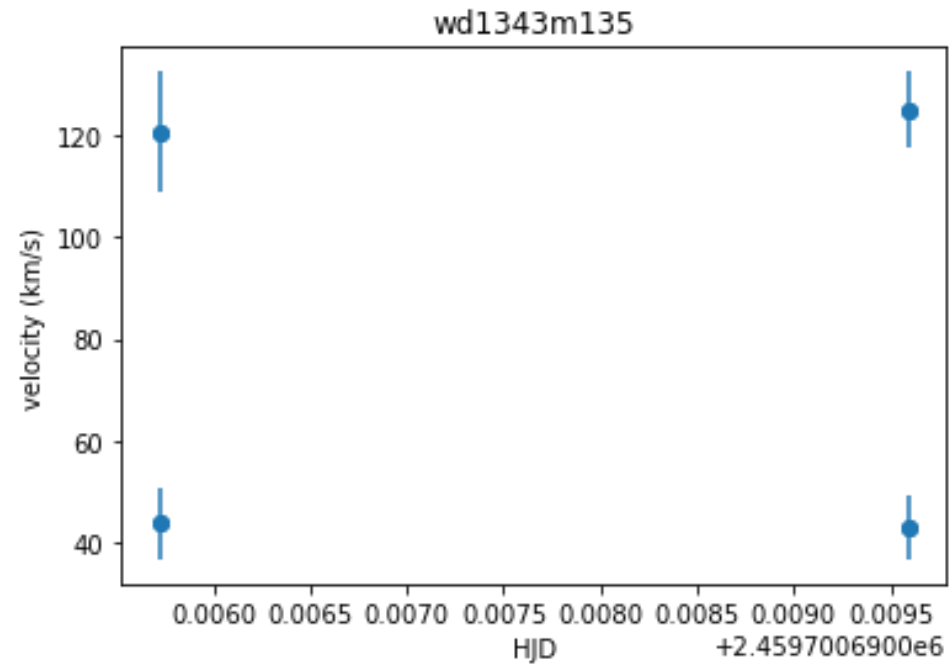
Wd1457m086 Time vs Velocity

Wd1457m086 Results

- Not enough velocity variation to conclude this is a binary system
- Would be a good system to gather further data on since there was still quite a bit of velocity variation

Weighted mean velocity (km/s)	χ^2	P-value	Log(p-value)
26.1+-0.9	21.1	0.02	-3.88

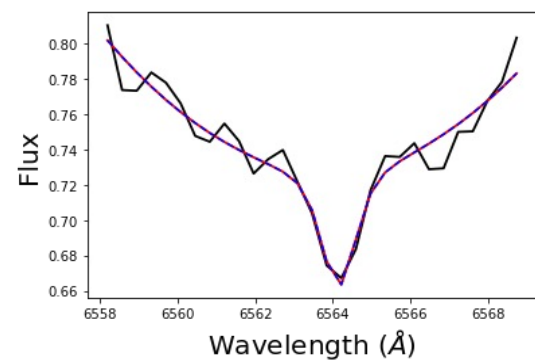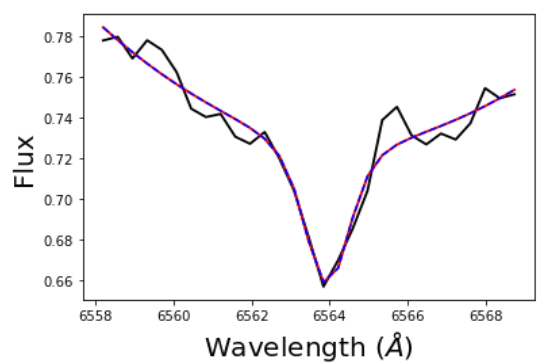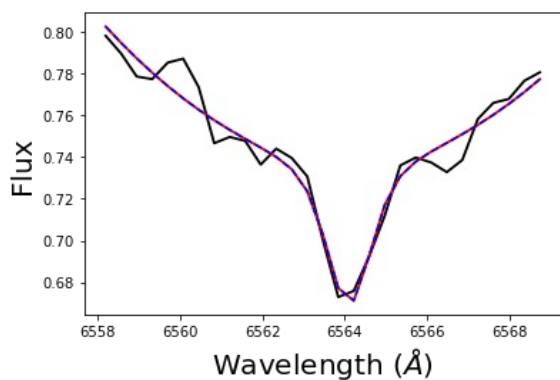Wd1343m135

Wd1343m135 Time vs Velocity
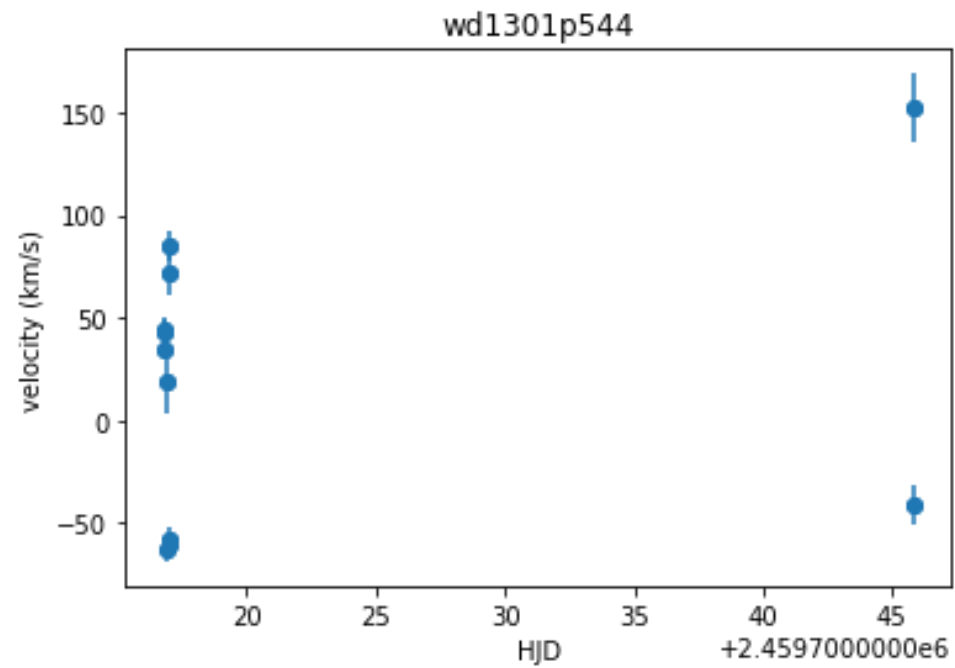
Wd1343m135 Results

- Double-lined binary white dwarf system
- Unfortunately, there are only two spectra for this system so follow up data is necessary

Weighted mean velocity (km/s)	χ^2	P-value	Log(p-value)
71.3+-3.7	106.4	6.7E-23	-51.1

Wd1301p544
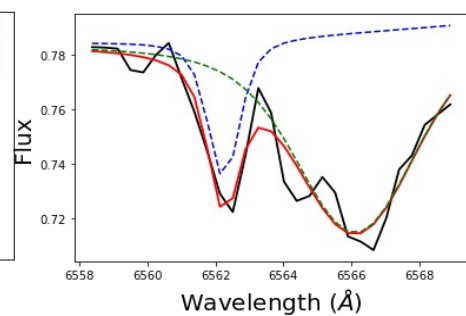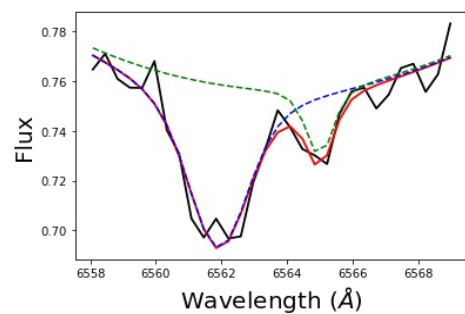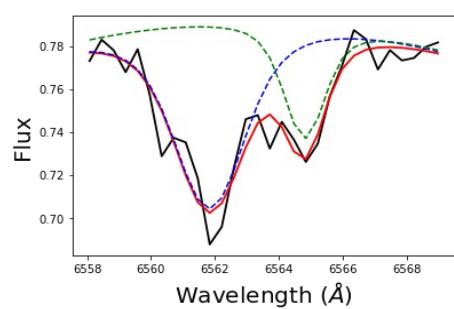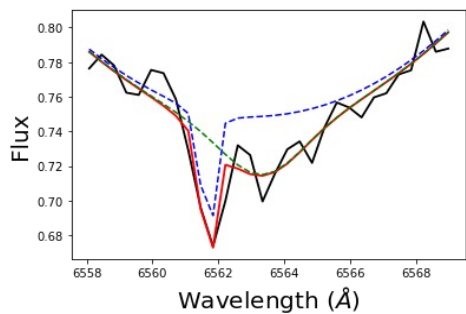
Wd1301p544 Time vs Velocity

Wd1301p544 Results

- Double-lined binary white dwarf system

Weighted mean velocity (km/s)	χ^2	P-value	Log(p-value)
5.9+-2.1	757.7	2.6E-156	-358.3

Conclusions

- Two double-lined binary white dwarf systems found
- One single-lined binary system
- Three targets did not have enough velocity variation to conclude they're in binary systems

Questions?