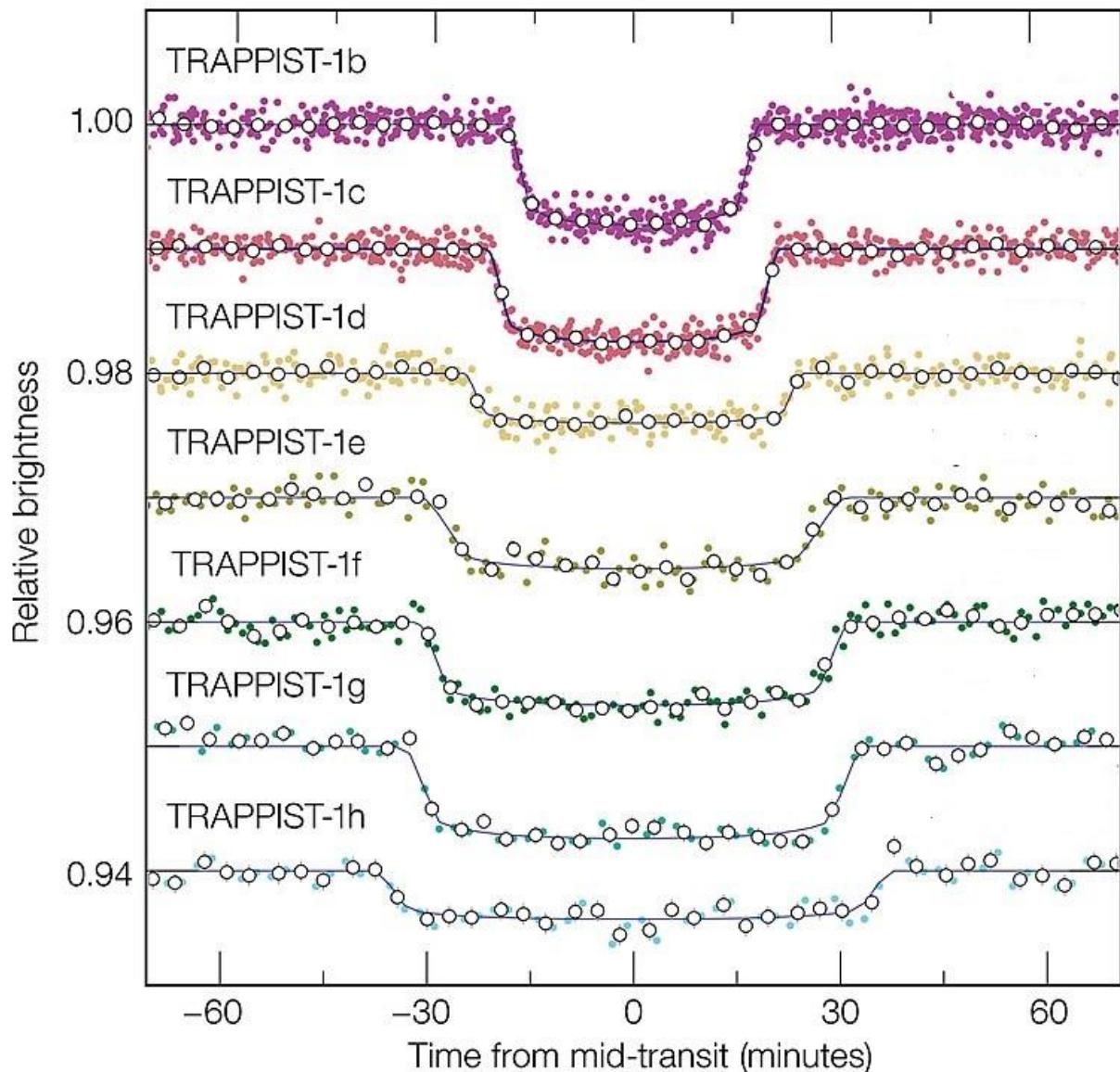


MyAO Finals 2022: Practical Round

There are 3 problems. Each problem is worth 10 points. Problems are not sorted by difficulty.

1 Problem 1

The figure below shows the light-curves of the 7 exoplanets that transit the star TRAPPIST-1 which is an ultra-cool red dwarf star in the constellation of AQUARIUS. These 7 exoplanets were discovered by the Transit Photometry Method.



Following the naming system, TRAPPIST-1b is the closest exoplanet to the star TRAPPIST-1. TRAPPIST-1c is the next closest exoplanet to the star and so on until TRAPPIST-1h which is the furthest exoplanet from the star.

From the 7 light-curves in the diagram, determine the periods of orbital motion (in Earth-days) of the 7 exoplanets orbiting TRAPPIST-1. (Assume that during the 7 transits of the exoplanets, these exoplanets transit across the full diameter of TRAPPIST-1

The radius of TRAPPIST-1 is 84,180 km.

The orbit of TRAPPIST-1b has a semi-major axis of 0.0115 AU.

The orbit of TRAPPIST-1c has a semi-major axis of 0.0158 AU.

The orbit of TRAPPIST-1d has a semi-major axis of 0.0220 AU.

The orbit of TRAPPIST-1e has a semi-major axis of 0.0290 AU.

The orbit of TRAPPIST-1f has a semi-major axis of 0.0380 AU.

The orbit of TRAPPIST-1g has a semi-major axis of 0.0470 AU.

The orbit of TRAPPIST-1h has a semi-major axis of 0.0620 AU.)

2 Problem 2

You are given the visible light spectra of six galaxies A to E with notable emission (blue) and absorption (red) lines labelled. Complete the table after the six figures. Here are the explanations for the headers

- $\lambda_{\text{H}\alpha}$ (\AA) is the observed wavelength of the H α emission line.
- λ_{OII} (\AA) is the observed wavelength of the OII emission line.
- $\Delta\lambda_{\text{H}\alpha}$ (\AA) is the difference between the observed wavelength and rest wavelength of the H α emission line.
- $\Delta\lambda_{\text{OII}}$ (\AA) is the difference between the observed wavelength and rest wavelength of the H α emission line.
- $z_{\text{H}\alpha}$ is the redshift corresponding to your calculations on the H α emission line.
- z_{OII} is the redshift corresponding to your calculations on the OII emission line.
- z is the average of $z_{\text{H}\alpha}$ and z_{OII} .
- v (km s^{-1}) is the recessional velocity of the galaxy.
- D (Mpc) is the distance to the galaxy.

The following information might be useful.

- The unit angstrom, \AA has the relationship $10 \text{\AA} = 1\text{nm}$
- The rest wavelength of H α is 6565\AA
- The rest wavelength of OII is 3728\AA
- $z = \frac{\lambda_{\text{obs}} - \lambda_{\text{emit}}}{\lambda_{\text{emit}}}$
- $1 + z = \sqrt{\frac{1+v/c}{1-v/c}}$
- $c = 299,792,458 \text{ ms}^{-1}$
- Hubble's Law, $v = H_0 D$ where $H_0 = 70 \text{ km/s/Mpc}$

If you have difficulty expressing v in terms of z , you can use the approximation $v \approx zc$. Note that this will incur a score penalty.

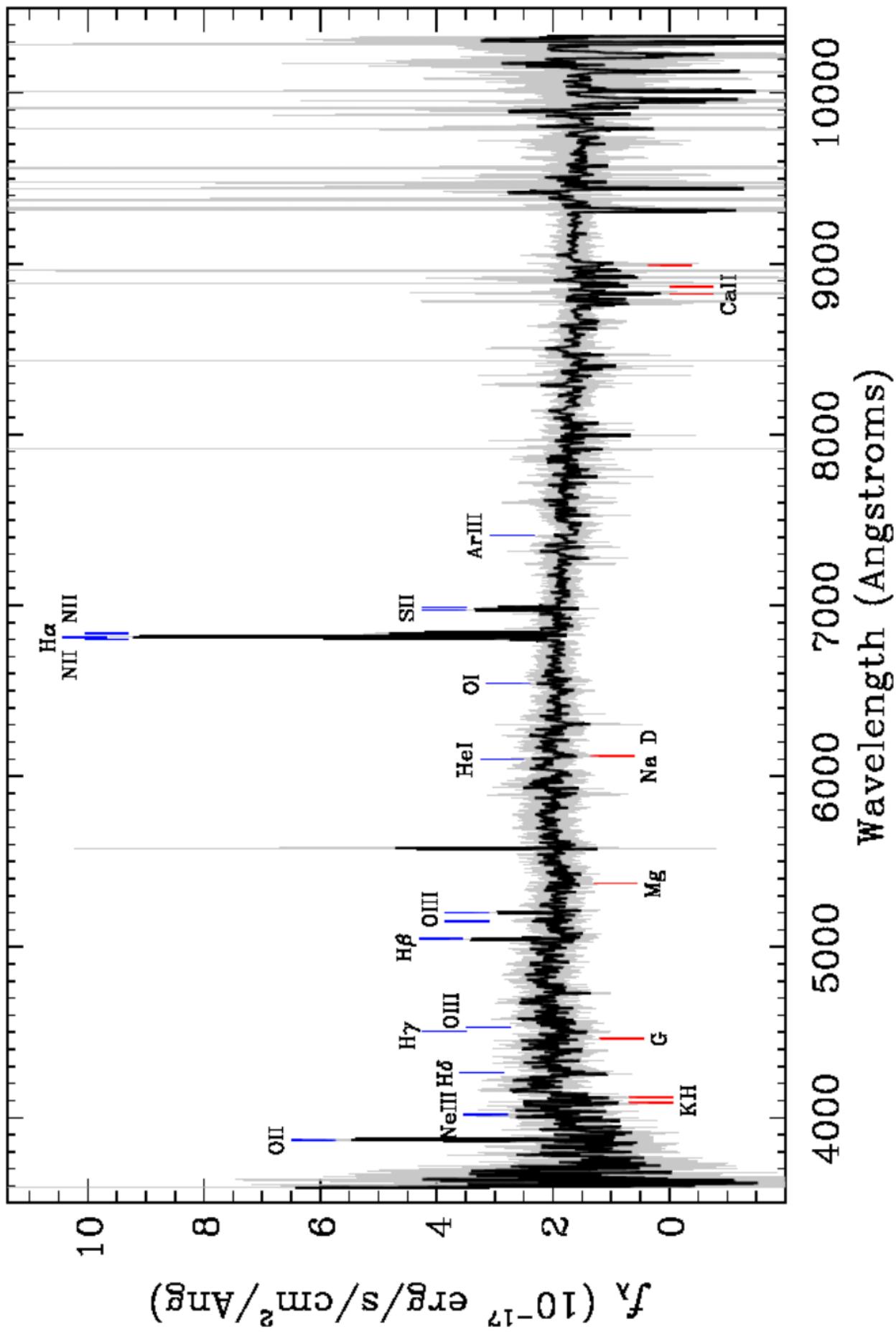


Figure 1: Galaxy A

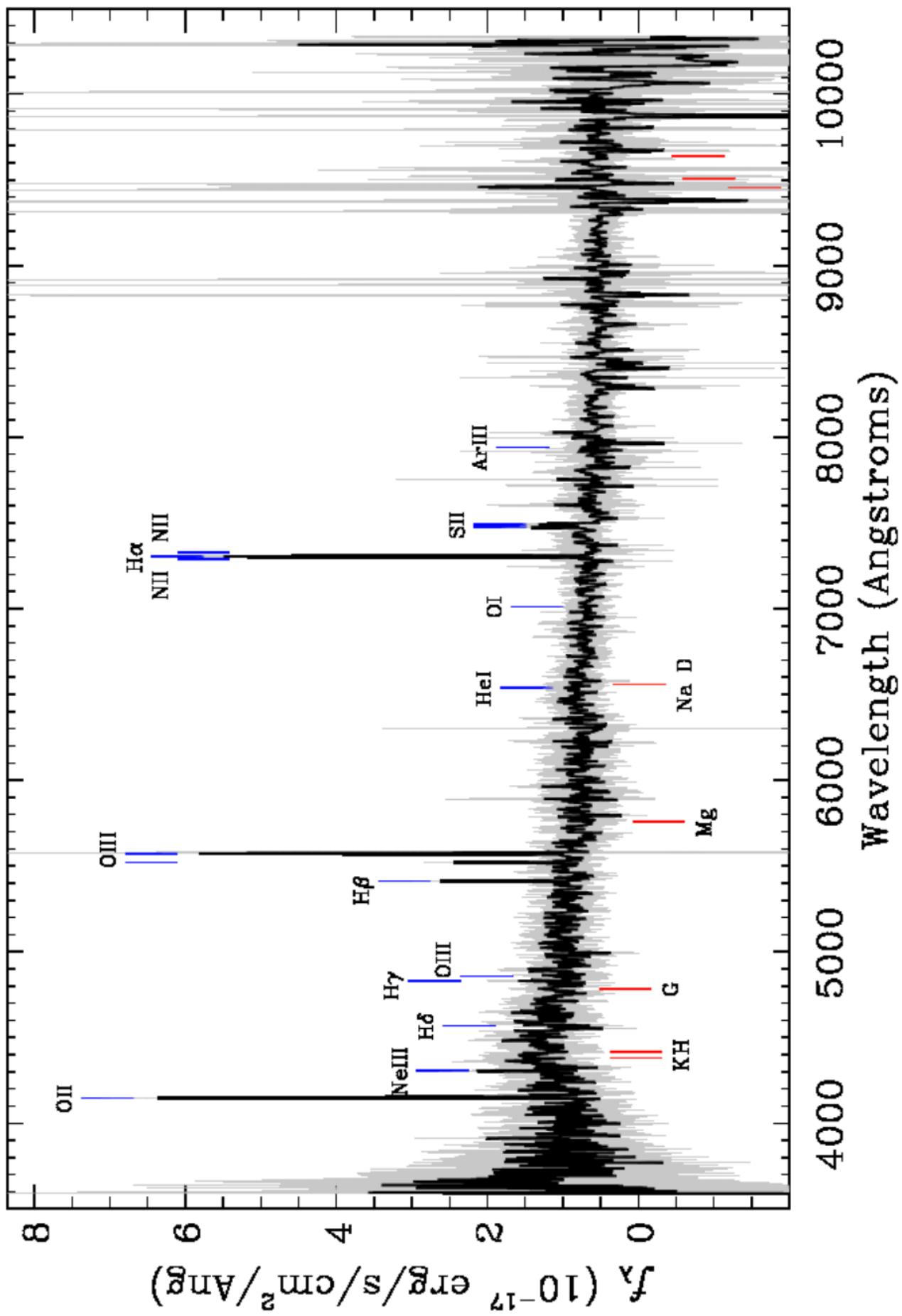


Figure 2: Galaxy B

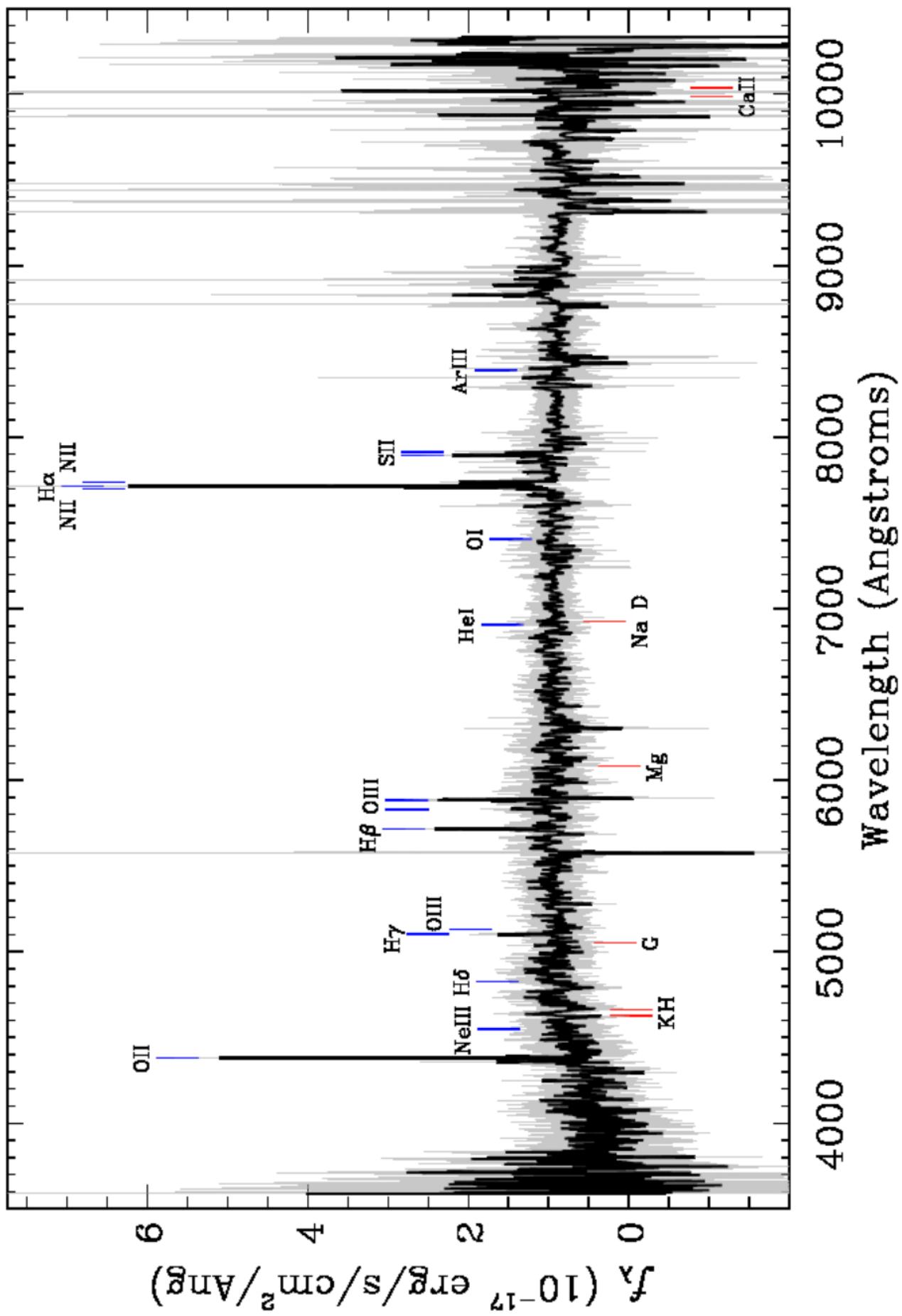


Figure 3: Galaxy V

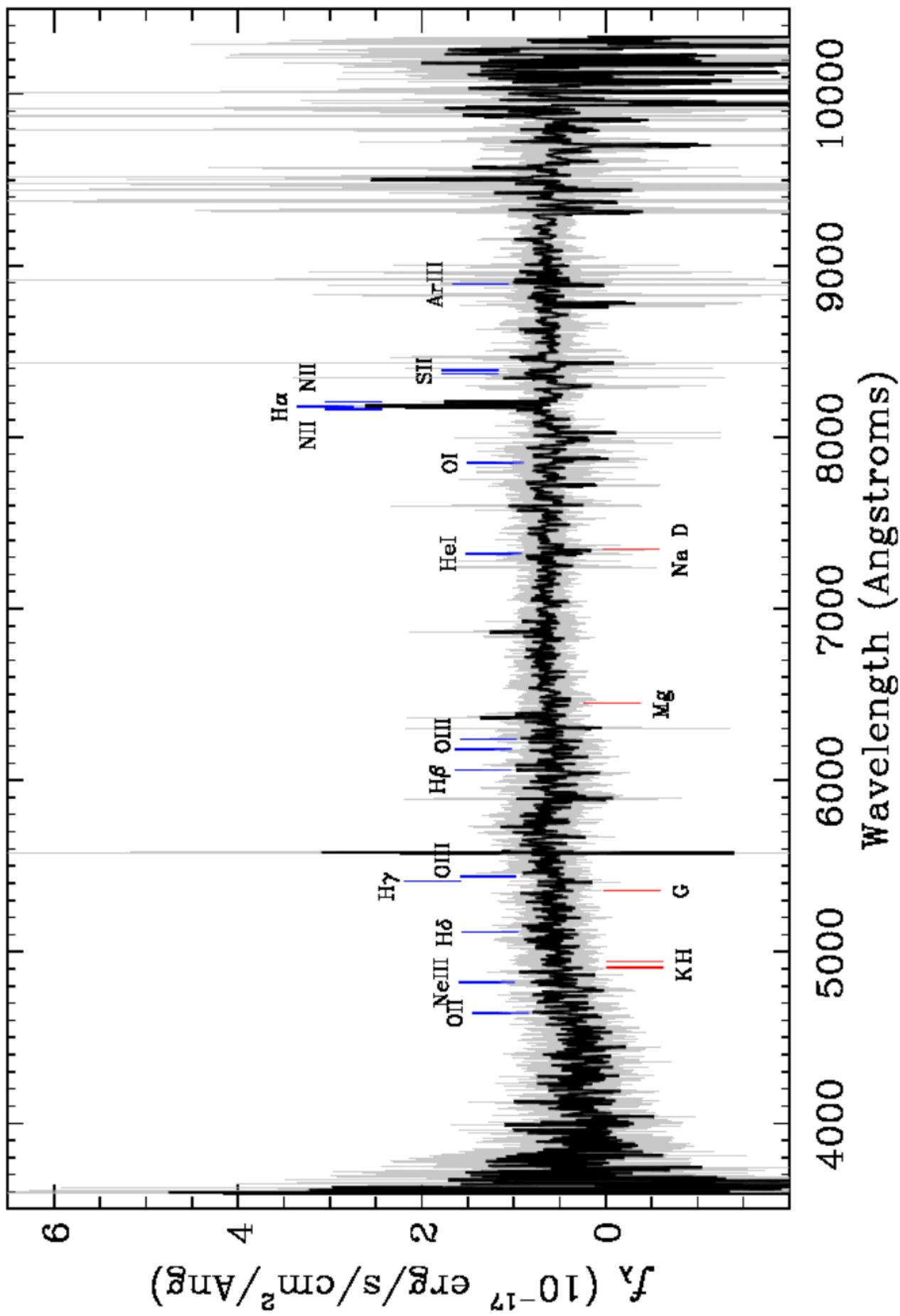


Figure 4: Galaxy D

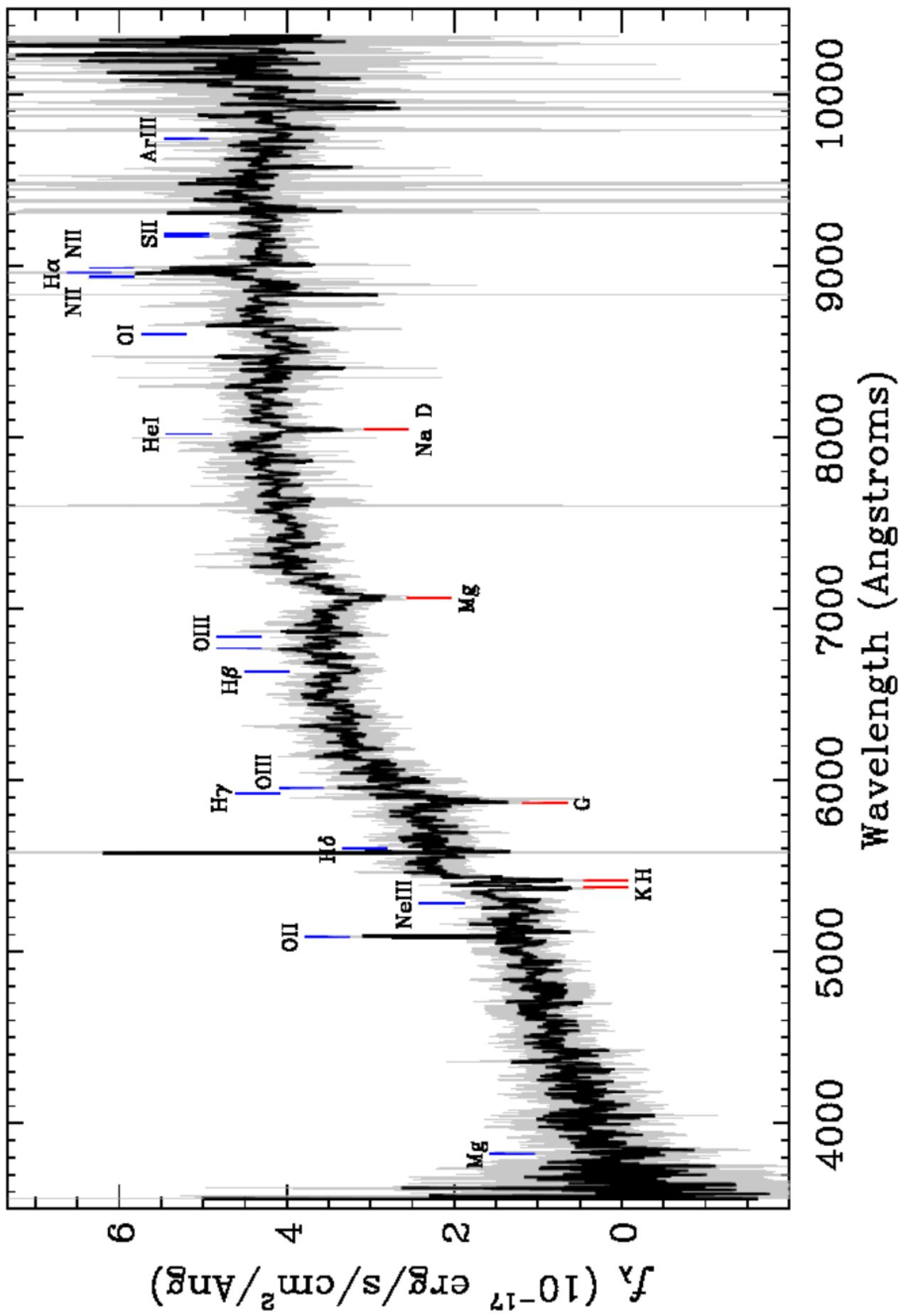


Figure 5: Galaxy E

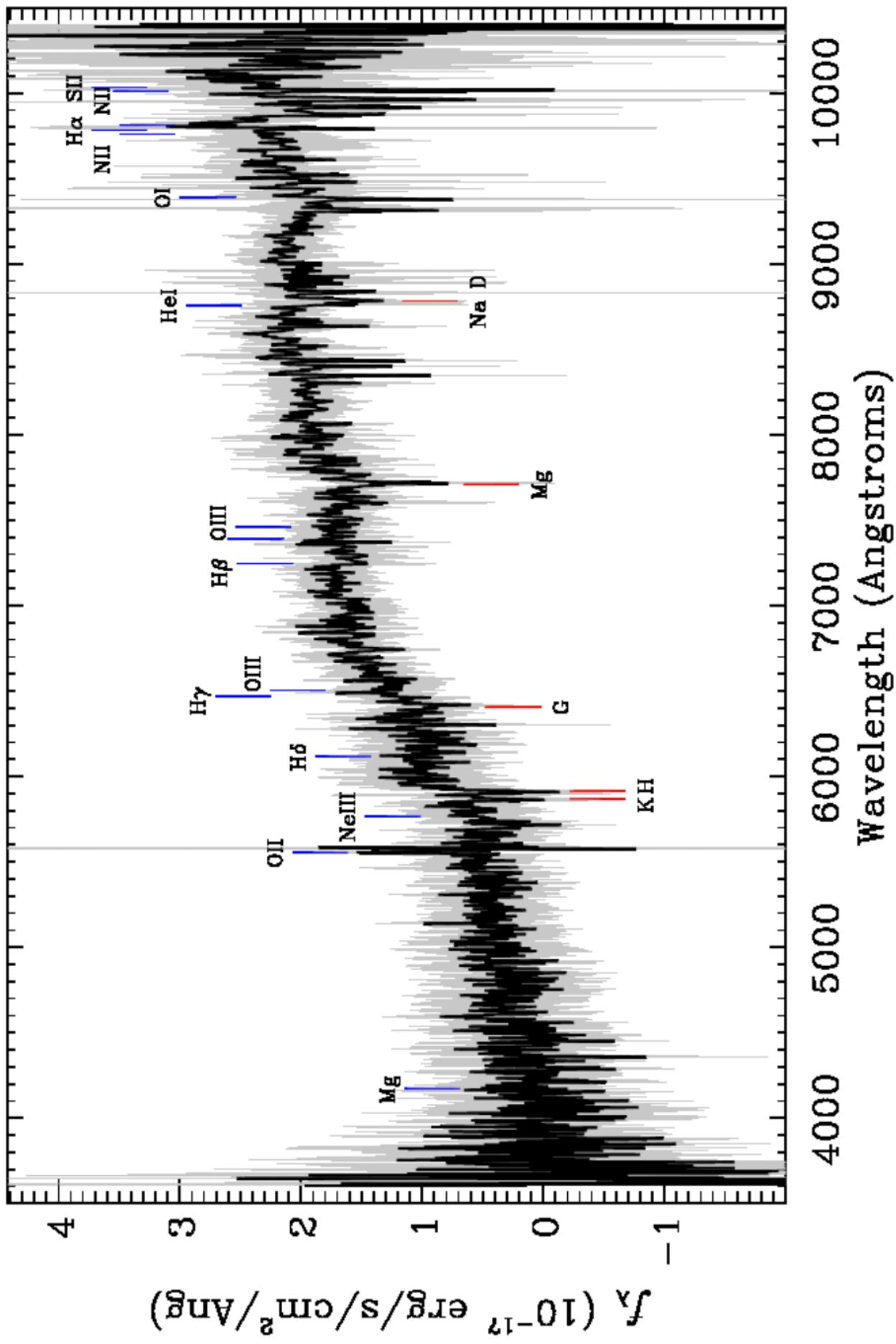


Figure 6: Galaxy F

1. Write down your equation for calculating v from z .
2. Copy the table below to your answer sheet and complete it.

ID	$\lambda_{\text{H}\alpha}$ (Å)	λ_{OII} (Å)	$\Delta\lambda_{\text{H}\alpha}$ (Å)	$\Delta\lambda_{\text{OII}}$ (Å)	$z_{\text{H}\alpha}$	z_{OII}	z	v (km s ⁻¹)	D (Mpc)
A									
B									
C									
D									
E									
F									

3 Problem 3

Data below is a sample from survey result from GAIA data release 2 of a small section of the sky, with a field of view of 2 arc-minutes, observing a star cluster. The explanation on the columns are as follow

- **Designation** is the star's designation based on the survey run
- **ra** is right ascension
- **DEC** is declination
- **parallax** is parallax measurement of the star
- **pmra** is proper motion in along the RA
- **pmdec** is proper motion along the DEC
- **BP-RP** is colour index, BP-RP in magnitude scale
- **bp-g** is Bp-G colour index in magnitude scale
- **g-rp** is G-Rp colour index in magnitude scale

designation	ra (deg)	DEC (deg)	parallax (mas)	pmra (mas/yr)	pmdec (mas/yr)	bp-rp (mag)	bp-g (mag)	g-rp (mag)
Gaia DR2 5911045876101163136	268.6732725	-62.95797388	0.035346927	-2.747837152	-4.011306292	0.8889027	0.3508816	0.5380211
Gaia DR2 5911047357868692736	268.69226	-62.94320783	5.334672108	-0.439949041	-4.63957735	1.271437	0.5886822	0.6827545
Gaia DR2 5911045876101143552	268.6932591	-62.96512409	-0.054874647	-1.650236919	-5.524856736	0.936821	0.4047031	0.5321178
Gaia DR2 5911047357872637568	268.6685437	-62.94123109	0.72390481	-4.324863447	3.481813972	1.451584	0.6441116	0.8074722
Gaia DR2 5911047353569955328	268.6623582	-62.93966589	0.454466531	-1.91441602	-4.944018941	1.609177	0.6741772	0.9349995
Gaia DR2 5911045811683988992	268.6516786	-62.96814676	0.238536739	-2.749121893	-4.884225005	1.545485	0.6802444	0.8652401
Gaia DR2 5911045910467068800	268.6383319	-62.96119536	0.054601778	-1.849106994	-4.855207369	0.8162727	0.2868423	0.5294304
Gaia DR2 5911045674245030016	268.7064336	-62.96774359	0.237330996	-1.42175612	-4.7647103	0.8508816	0.3458557	0.5050259
Gaia DR2 5911045910460886912	268.6557342	-62.9636614	0.294043411	2.736804761	-18.38743159	1.920782	0.8467331	1.074049
Gaia DR2 5911047147411481216	268.717263	-62.96112876	0.901134811	-0.561064268	-4.400704205	1.663218	0.7971306	0.866087
Gaia DR2 5911045807381673728	268.6260166	-62.96278639	0.149021227	-0.938978045	-5.319009921	1.68104	0.8410473	0.8399925
Gaia DR2 5911045910469773056	268.6224786	-62.95047343	1.077163731	-0.648972099	-3.64314446	2.46719	0.9316063	1.5355583
Gaia DR2 5911047392231960064	268.6653616	-62.92936522	0.322107837	-0.595207989	-4.098902721	1.190125	0.5273933	0.6627321
Gaia DR2 591104667067745360	268.6186966	-62.95506832	0.413299776	-1.031643514	-3.751552674	1.195462	0.5296707	0.6657915
Gaia DR2 5911047186068569216	268.7269734	-62.94522935	-0.344003832	-1.665040995	3.70233005	0.4404087	-0.054049	0.4944572
Gaia DR2 5911045674241195264	268.7311587	-62.96648606	1.025491803	-1.543724115	-3.611270115	1.873917	0.7262173	1.147699
Gaia DR2 5911045669942693760	268.7327342	-62.97192517	0.405133858	-1.255678619	-3.790852347	1.04237	0.430397	0.6119728
Gaia DR2 5911047078691993856	268.7434949	-62.96214387	0.605958112	-2.127562689	-3.68992146	1.4111715	0.5108852	0.9008293
Gaia DR2 5911045846039881728	268.6650341	-62.95831193	-0.140492359	-7.89766198	-17.03217025	2.097893	0.9504356	1.147457
Gaia DR2 5911047289153160320	268.7213425	-62.92932972	0.22305873	-1.208848777	-5.371177117	1.036034	0.4230251	0.6130085

1. Plot a graph to distinguish the background star(s) from the members of the star cluster on a graph paper.
2. Which star(s) are not part of the star cluster? Explain.
3. What type of star cluster do you think this is? Explain.