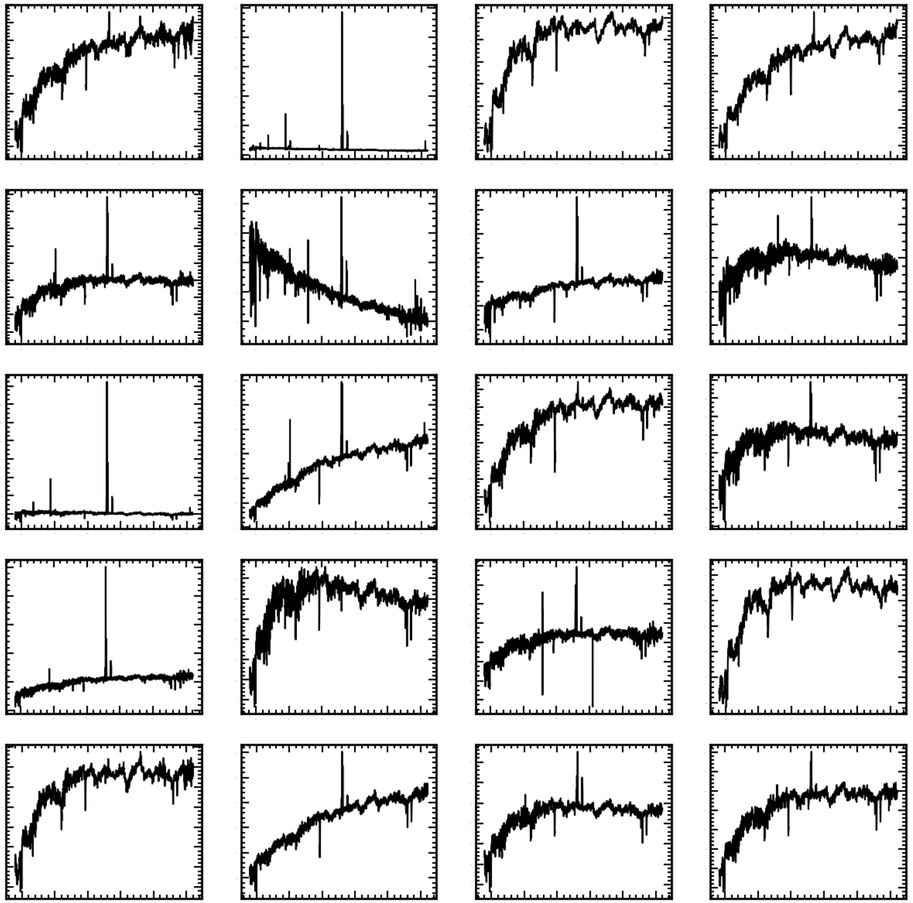
Spectroscopy

Goal

- Understand the concept of a spectrum.
- Derive redshifts from spectra

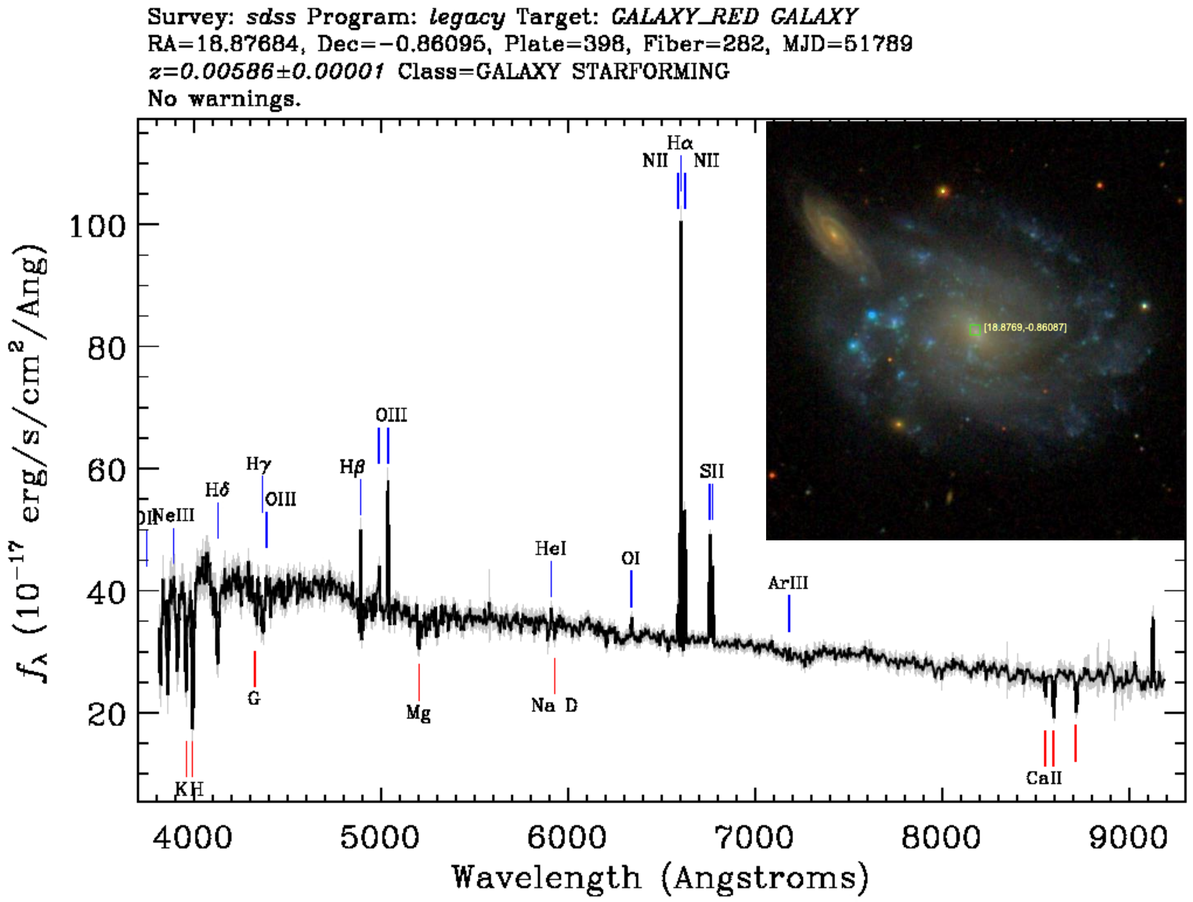
Goal



spec z	
0	0.01248
1	0.00506
2	0.01501
3	0.01286
4	0.00525
5	0.00340
6	0.00687
7	0.00431
8	0.00310
9	0.00249
10	0.00868
11	0.00286
12	0.00052
13	0.00514
14	0.00460
15	0.02159
16	0.00641
17	0.00641
18	0.00552
19	0.00463

Spectrum

- In astronomy, a spectrum referst to the intentsity of light as a function of frequency or wavelength.
- From spectrum, we can know
  - composition
  - kinematics

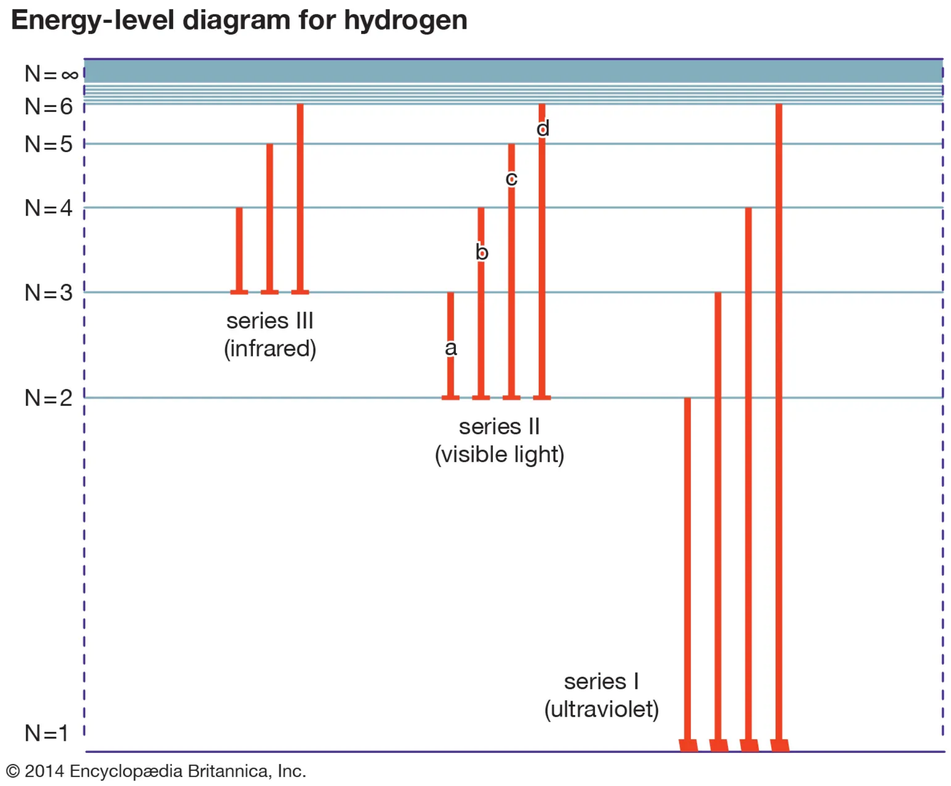


Can science figure out everything?

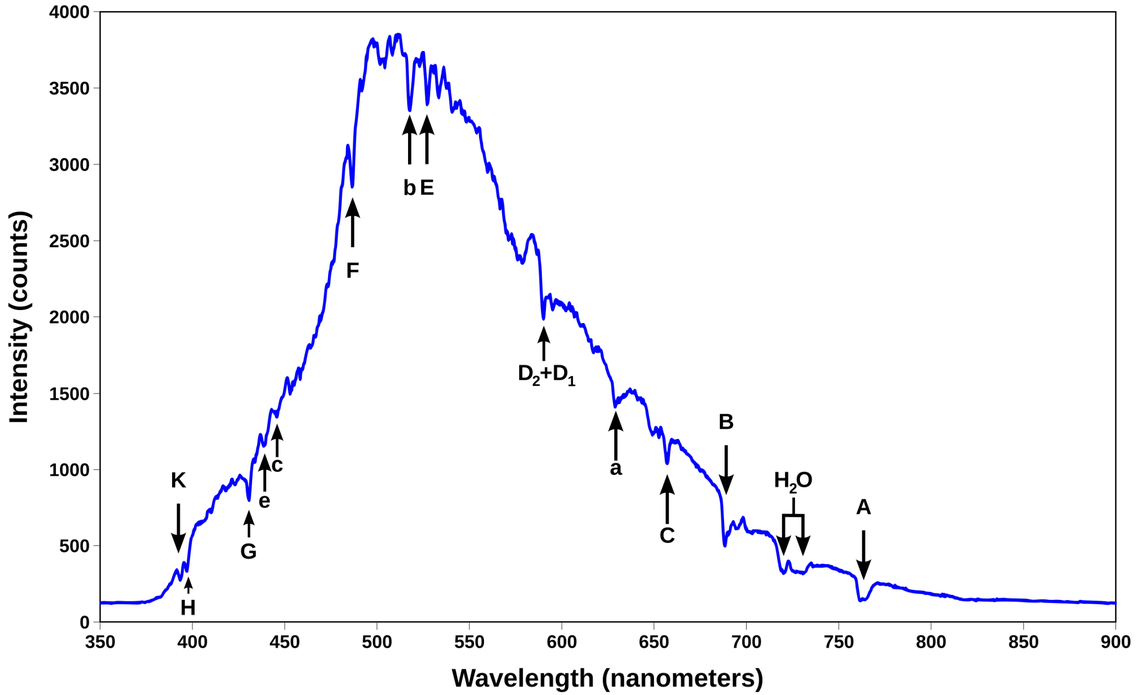
Of all objects, the planets are those which appear to us under the least varied aspect. We see how we may determine their forms, their distances, their bulk, and their motions, but we can never known anything of their chemical or mineralogical structure; and, much less, that of organized beings living on their surface …

- Actually, it was an incorrect exmample.
- We can know the chemical composition from spectra!

Spectral lines



<https://cdn.britannica.com/96/62996-050-1F7436C9/hydrogen-diagram-energy-levels-states-lines-values.jpg>



<https://en.wikipedia.org/wiki/Spectral_line#/media/File:Spectrum_of_blue_sky.svg>

- Each atomic element emits or absorbs the ligth with specific wavelengths

Radial velocity from spectra

- Red(blue)shift: increase(decrease) of wavelengths of elctromagnetic waves (i.e. decrease(increase) of frequency/energy).

$$z = \frac{\lambda_{obs} - \lambda_0}{\lambda_0}$$

- The definition of the redshift is nothing to do with a radial velocity.

What causes redshift?

- Physcis relates the redshift with the radial velocity.

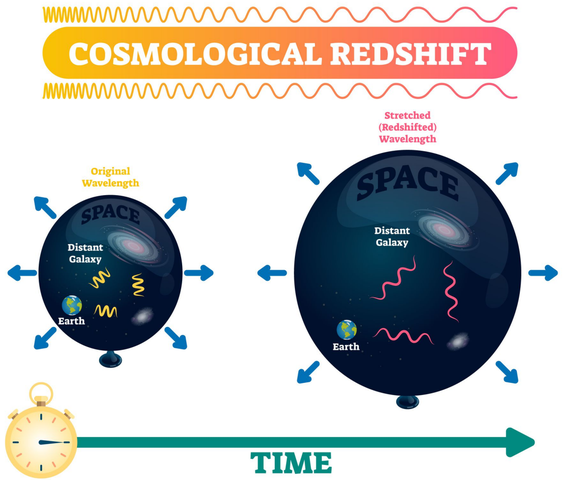
  1. Doppler shift: redshift resulted from the motion of the object.

$$\lambda_{\text{obs}} = \sqrt{\frac{1+v/c}{1-v/c}}\lambda_0 \approx \left(1+\frac{v}{c}\right)\lambda_0$$

<https://commons.wikimedia.org/wiki/File:Dopplerfrequenz.gif>

  2. Cosmological redshift: redshift resulted from the cosmic expansion.

$$\lambda_{\text{obs}} := \left(1+\frac{v}{c}\right)\lambda_0$$



You will learn about comological expansion in the next class and astronomy class.

<https://cosmosatyourdoorstep.com/2024/06/24/cosmological-redshift-demystified/>

Reference

- (수업 자료/숙제를 만들면서 참고한 reference들 나열)
- (수업할 때 학생들에게 무엇에 대해 더 알아보고 싶으면 이 reference를 보면 좋다라고 설명 e.g., aperture photometry에 대한 일반적인 설명은 ~에 잘 정리되어있고, photutils를 사용하는 방법을 알고 싶으면 ~을 보면 된다.)

How to measure the redshift?

Measurable

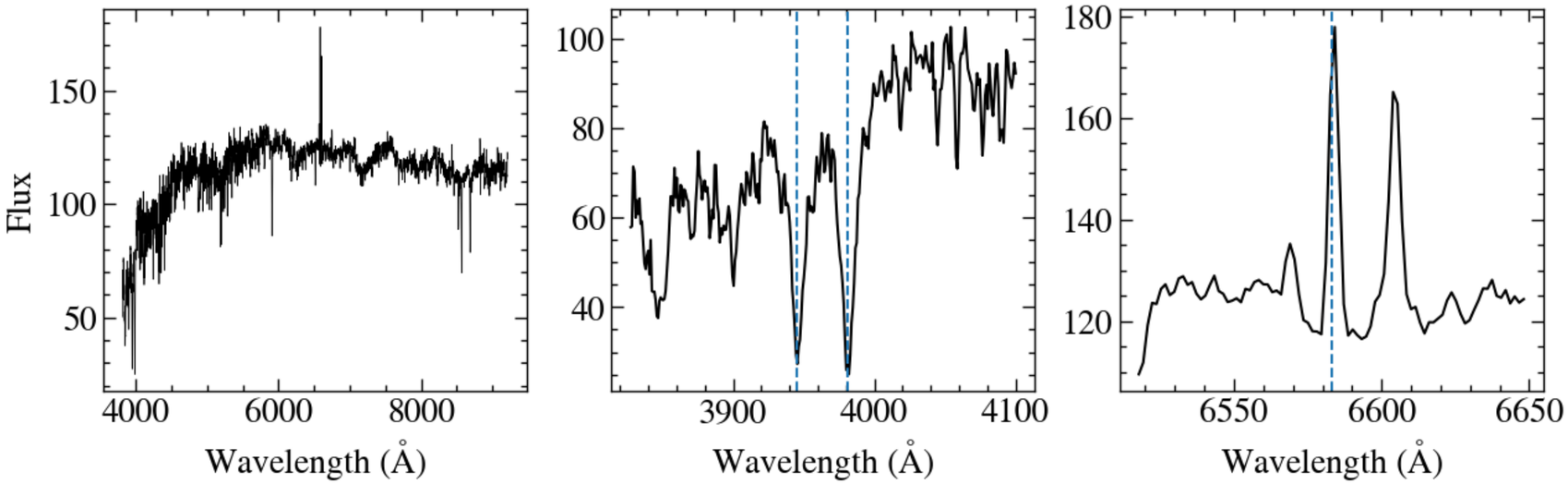
$$z = \frac{\lambda_{obs} - \lambda_0}{\lambda_0}$$

how can we know?

- We know the rest frame wavelength of atomoic spectral lines!
  - ✓ Ca H & K : 3968 & 3934 Å
  - ✓ [O III] : 4959 & 5007 Å
  - ✓ Hα : 6563 Å

Practice: measure the redshifts of 20 galaxies

- Measure the redshifts of 20 galaxies based on Ca H&K lines and Hα lines.
- Open measure_redshift.ipynb
- Guess the wavelengths of either Ca H&K or Hα lines.
- The code upadates the redshifts of the galaxies in measure_redshift.txt



HW

- Complete to measure the redshifts of 20 galaxies.
- You will use your measurements in the next class.