Astro Jargon Explained

Oscar A. Chavez Ortiz and Kay Guo

June 5 2023

1 Introduction

This document will go over very briefly certain Astronomical Terms that we say a lot and you are bound to hear throughout your 10 weeks here. We will not cover these terms in depth as there is an existing seminar, later on in the REU that will do that. Instead, we cover some astronomical terms at a very basic level, and what they mean so that you can follow along in the seminar. Below is a list of all the terms we will cover and Section 2 has the definitions of all the terms.

Coordinates	RA	DEC
Parsec	Gyr	Spectrum
Wavelength	Flux	Magnitude
redshift (z)	Observed-Frame	Rest-Frame
Spectroscopy	Photometry	Emission/Absorption Lines

Table 1: Caption

2 Terminology

Coordinates - coordinates refer to the two-value pair that refers to a source's position in the sky. Typically we denote this using Right Ascension (RA) and Declination (DEC). The units for this are normally in degrees with RA going from 0° - 360° and DEC ranging from $-90° - +90°$.

RA: Short for Right Ascension and is the same as longitude in the global position.

DEC: Short for Declination and is the same as latitude in the global positions. This denotes how high or low the source is relative to the celestial sphere equator.

Parsec (pc): This is a unit of measurement that we use quite frequently in astronomy as the conventional meters or kilometers make the number be too large. 1 parsec is the same as $3.086x10^16$ m. For reference, we usually use parsec when talking distance to the nearest stars in the Milky Way galaxy. When we are talking about the distance between galaxies (ie: from one galaxy to another, we usually use MegaParsec (Mpc) and this is $1x10^6$ pc.

Gyr: Since astronomical phenomena can take a long time to pass, such as the lifetime of a star for example, we usually denote the times in Giga-years which is the same as $1x10^6$ years.

Spectrum: A spectrum is a visual representation of how bright the source is at a given wavelength. Some sources can be super bright at small wavelengths, while others are super bright at longer wavelengths. Depending on the source you can also have absorption or emission lines and these tell you a lot about what is going on inside of a galaxy or the star.

Wavelength: Light is treated as a wave and the wavelength represents the distance between successive peaks. The smaller the wavelengths the higher the energy, the larger the wavelength the lower the energy. You can relate wavelength and frequency using the speed of light formula. c = $\lambda\nu$, where λ is the wavelength and ν is the frequency.

Flux: You can think of flux as the intensity of light at a specific wavelength, or integrated over a range of wavelengths. But in short, it is a measure of how bright a source is. Usually, we denote the flux in F_λ or F_ν units. F_λ has units of ergs/s/$cm^2/\mathring{A}$ while F_ν has units of ergs/s/cm^2/Hz.

Magnitudes: Magnitudes are another way of describing how bright a source is and directly relate to flux very closely. There are two types of magnitudes:

1. Apparent Magnitude: this is how bright it looks to us. So something that is bright but further away can look dim, whereas a source that is not that bright but closer could look brighter. This is very much apparent from our point of view. To compare sources and study them we need to convert their Apparent Magnitude to Absolute Magnitude.

2. Absolute Magnitude: This is the brightness of a source if we were to place the source at a distance of 10 pc away from us. This is what we use when we want to compare two sources as we are "putting" the two sources at the same distance and we can tell with this which one is actually brighter than the other one.

The tricky thing about magnitudes is that it works backward from what you would expect. A high magnitude value means the source is actually fainter than a source with a lower magnitude. So in short, high magnitudes values = faint, and low magnitudes = bright.

A useful equation to keep in the back pocket when dealing with magnitude is the conversion from flux in F_ν to apparent magnitude in the AB magnitude system.

$m_{AB} = -2.5\log_{10} f_\nu - 48.60$

To convert to absolute magnitude we use:

z	Time the light has been traveling	Distance to the object now
0.0000715	1 million years	1 million light years
0.10	1.286 billion years	1.349 billion light years
0.25	2.916 billion years	3.260 billion light years
0.5	5.019 billion years	5.936 billion light years
1	7.731 billion years	10.147 billion light years
2	10.324 billion years	15.424 billion light years
3	11.476 billion years	18.594 billion light years
4	12.094 billion years	20.745 billion light years
5	12.469 billion years	22.322 billion light years
6	12.716 billion years	23.542 billion light years
7	12.888 billion years	24.521 billion light years
8	13.014 billion years	25.329 billion light years
9	13.110 billion years	26.011 billion light years
10	13.184 billion years	26.596 billion light years

Figure 1: Table that shows the time and distance for a given redshift. Note that the redshift time and distance is not linear as the same Δz can correspond to a different amount of time passing and distance traversed.

$m - M = 5(log_{10}(d) - 1)$ where m is the apparent magnitude, M is the absolute magnitude, and d is the distance to the source in parsec.

redshift (z): One of the most used terms in astronomy is redshift and redshift corresponds to the change in wavelength of light caused by the expansion of the universe and is typically denoted by the variable z. As the universe expands this causes light that was emitted to be physically stretched because space itself is being stretched. This in turn makes the wavelength of an emission line longer or redshifted. We can also use redshift as a proxy for distance from us. Redshift 0 is typically used to denote sources near us, in the galaxy, or very nearby and as you go up in redshift you are going further back in distance but also further back in time. See Table 1 for how time and distance relate to redshift.

One of the most useful equations to keep in mind with redshift is:

$$z = \frac{\lambda_{obs} - \lambda_{rest}}{\lambda_{rest}} \tag{1}$$

We use Equation 1 to find how far away a source is and to convert observed quantities to rest-frame quantities.

Observed Frame: The observed frame of a source is what we actually observe. Since the universe is expanding when a source emits light across all wavelengths that light gets stretched due to the expansion of space which means that emission lines from certain lines that normally emit at one wavelength will get stretched to longer wavelengths, appearing to shift in location. If we have a detector that is in the window to see this emission line we will be able to see it. This line is in our observed frame. To revert back to what was actually emitted we need to convert the observed to rest-frame by solving for λ_{rest} in Equation 1.

Rest-Frame: This is the concept that you are in the galaxy, not moving relative to it, and that everything is at rest. This is useful as emission lines have pre-designed lines that they emit at. For example, all the elements have emission lines that emit at very specific wavelengths and you can use this in conjunction with what you observe to figure out the redshift of a source.

Spectroscopy: This is one of the ways that we gain information about stars, planets, and galaxies. We do this by splitting up the light to characterize how intense the light is at a variety of wavelengths. Spectra can have emission features, which are signs of hot gas being heated up by stars and the free electrons cascading down the atom, providing a boost in intensity. Or absorption features where cold gas absorbs the light at very specific wavelengths and you get a reduction in intensity as that light has gone to excite an atom, and when it cascades down it remits in a random direction. See some examples of different spectra in Figure 2.

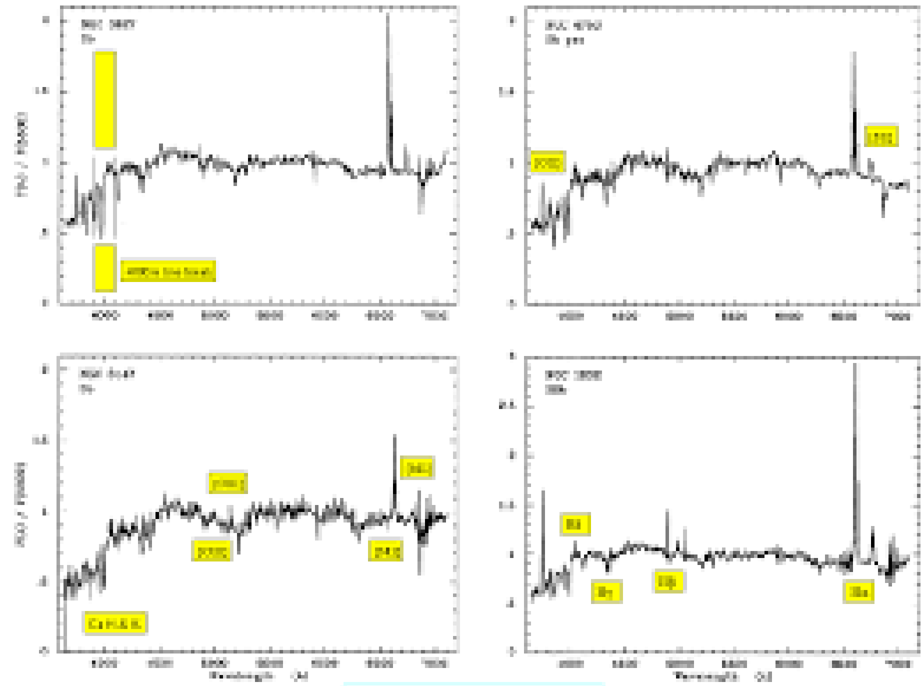

Figure 2:

Photometry: Another way to gather information about a source is using photometry. What this entails is taking images at various wavelength intervals and then at every image we measure the flux of the source by counting up how many photons we detect. If you see Figure 3, you can see that there are these filters labeled u, g, r, i, z with photometry we take an average of the spectrum over these filters and then we have fancy tools that convert photon counts to flux using a technique called flux calibration.

Since we are adding up the flux across the wavelength information we are in a sense getting the average flux across that filter pass but we can use a technique called SED fitting where we apply templates and try to fit the observed data to learn more about these sources.

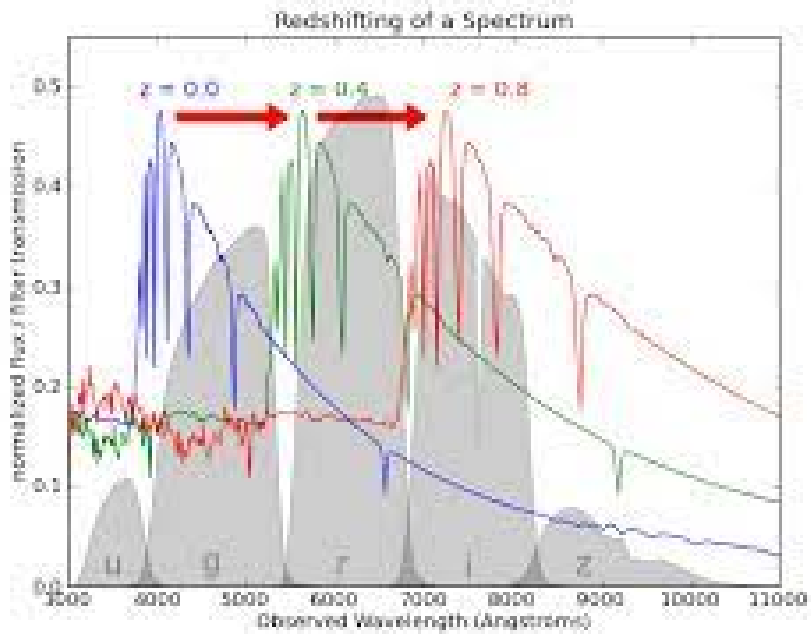

Figure 3: SED

Emission/Absorption Line: Emission lines are made when stars produce lots of ionizing photons and those ionizing photons remove electrons from elements within the gas. As the electrons recombine with the atoms they cascade down the energy levels and as the electrons cascade down photons are released at specific wavelengths which we see as a boost in intensity. Absorptions lines are the opposite where light passes through cold gas and the lines get absorbed by the gas at very specific wavelengths removing the intensity of light.

3 Cosmology

Here we will go over some cosmological terms that you may hear in the Astropy Seminar.

3.1 Terminology:

H_0: This is the Hubble constant and is one of the most important cosmological parameters. Right now it is currently accepted to be of order 70 km/s/Mpc.
Cosmologial Distances: The one most used is the Luminosity distance and this is the one that is one we are most familiar with. When we write out the Flux Equation we have Flux = $L/4\pi R^2$, the luminosity distance is equivalent to the R in this equation but takes into account the expansion of the universe

in the calculation of it. More useful cosmological distances and what they mean can be found here: Cosmology Distances