

Photometric redshift survey

Abstract

Photometric redshifts and redshift surveys are essential to Astronomy and astrophysics. They allow us to analyze objects that are too faint to use spectroscopy. Here we use a template fitting program called Eazy-py to compute redshifts easily by just getting their magnitudes, Fluxes and errors. It uses a predetermined template and a computational neural network called Photo-z to determine the redshift. We use about 12 galaxies in this survey but could use an endless number of galaxies as this program will calculate it within minutes if that. In our example we manage to get our errors that were 10000% to getting closer to about 10%. Our Data in the end wasn't best, but given more time and resources we could have gotten very precise results.

1 Introduction

1.1 Getting started

Getting a photometric redshift has always been hard. Redshifts are The get a photometric redshift it was “originally determined by calculating the expected observed data from a known emission spectrum at a range of redshifts.” What are redshifts? “the displacement of spectral lines toward longer wavelengths (the red end of the spectrum) in radiation from distant galaxies and celestial objects. This is interpreted as a Doppler shift that is proportional to the velocity of recession and thus to distance.”

1.2 History of redshift

The history starts off in the 1800s with wave mechanics and the Doppler effect. In 1842 a man named Christian Doppler discovered a phenomenon where an increase or decrease of a frequency of a wave, no matter if it be a light or sound wave, as an observer moves to or away from the object. Now it was only theorized that it was for all waves at this point since it wasn't proven yet until in 1845, but only for sound waves. A Danish man named Christian Ballot confirmed that the doppler effect was real. For light and other waves, no one still believed him as there was no proof and the information that a star's temperature was the only contributing factor to its color. Cut to 3 years later, a French physicist, Hippolyte Fizeau measure saw a shift in the spectral lines and said it was due to the doppler effect. 20 years later, in 1868 william huggins found a velocity of a star moving away from us using these shifts in the spectral lines. Soon after , optical redshift was discovered and then another 20 years later scientists with the names Vogel and scheiner found the annual doppler effect which is the annual doppler shift of stars near the ecliptic due to our own earth's velocity(wiki).1901 Aristarkh Belopolsky found optically a redshift using rotating mirrors. The term redshift itself was first printed in 1908 by Walter Adams. And then in 1912 Vesto slipher found out that a lot of spiral galaxies actually do have a good amount of redshifts. With all the evidence discovered in the following years, it gave evidence for the big bang theory and an expanding universe.

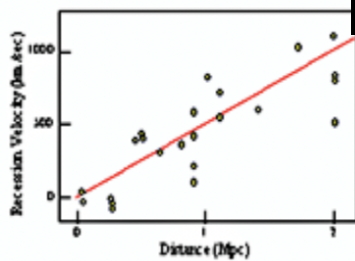
1.3 Hubble's law and red shift

For objects more than 1 billion light years away, direct observation of these far objects for redshift didn't work very well until Hubble came along. In 1929 Hubble discovered that most

galaxies are moving away from us. This was a redshift. Red shift was larger for objects that were further away from earth. The graphs below made by Hubble and Humason show this. The velocity is $v = H \times d$ where v is the radial outward velocity and H is the Hubble constant. The Hubble constant is the rate of the universe's expansion.

Hubble's law or Hubble Lemaitre law is “the observation in physical cosmology that galaxies are moving away from earth at speeds proportional to their distance.” This means that the further the galaxy from us, the faster it is going.

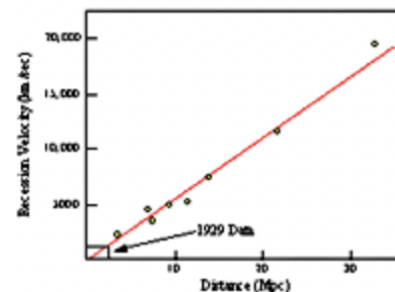
Hubble's Data (1929)



$$v = H \times d$$

$$t_0 - t_e \approx H_0^{-1} z$$

Hubble & Humason (1931)

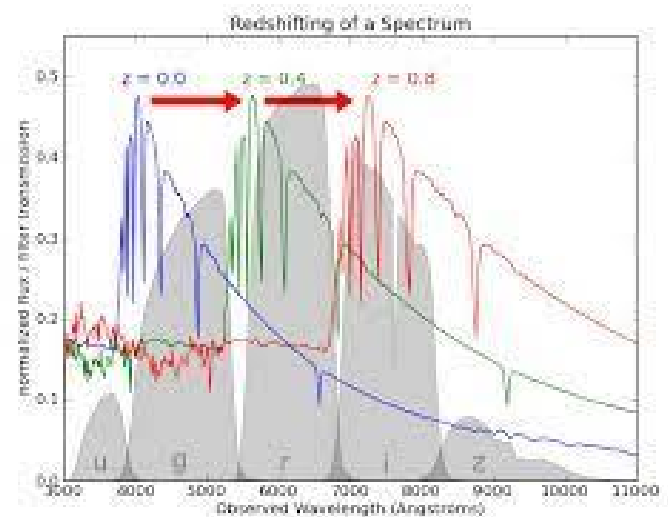
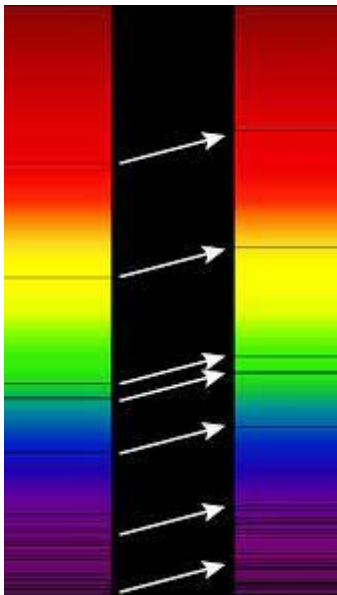


1.4 Spectroscopic vs photometric redshift

The usual way to determine is through spectroscopy. This method uses a telescope with a spectrometer. The spectrometer is used to measure the absorption spectrum of the desired object in the sky. After you get these measurements you would compare them to the Hydrogen emission spectrum. If you calculate the difference between the wavelengths you can determine the redshift from that. Spectroscopy is easier to do and will provide more accurate answers. But if

you don't have the machinery or have very faint objects you are looking at then Photometric redshift is the way to go.

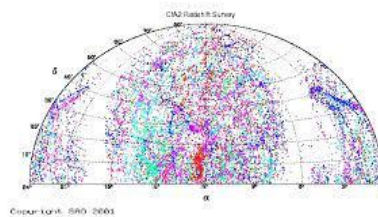
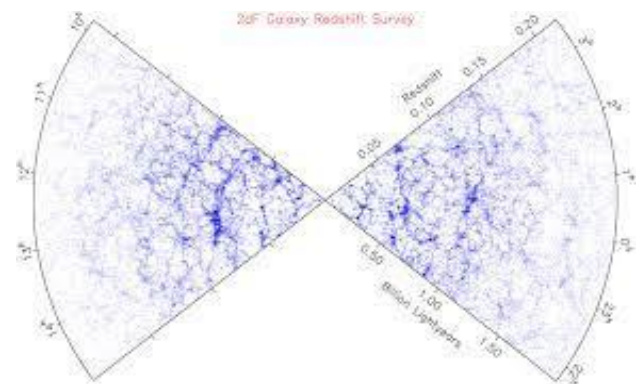
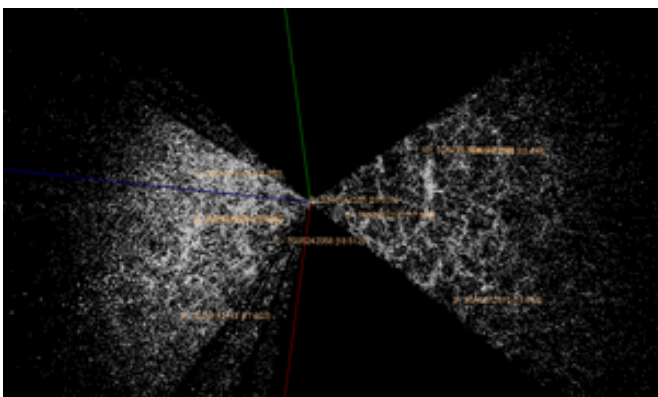
With photometry it's a tad different. “a photometric redshift is an estimate for the recession velocity of an astronomical object made without measuring the spectrum”(wiki). This is specifically helpful when using spectroscopy isn't feasible. This technique was first used in the 1960's but was quickly replaced by spectroscopy. And then we saw a resurgence of using photometric redshift due to enormous sky surveys conducted around the 2000's and a lot of the objects were very faint so using spectroscopy only worked on a small amount of these objects. Using spectroscopy will be usually more accurate than photometric. Think of photometric as a very close estimation. Below are 2 pictures showing what you get from spectroscopy and photometry respectively.



1.5 Redshift survey

A redshift survey is a survey of a section of the sky to measure the redshift of celestial objects. Mostly galaxies as they are really far away from us and the galaxies that are really far,

we can't really see their individual stars very well. But sometimes it is used to find quasars or clusters of galaxies. You can use the red shift of these objects to determine the distance between us and the object in question. You do this by taking the redshift and putting it with the angular position data. You can use this survey to measure "detailed statistical properties of the large-scale structure of the universe. In conjunction with observations of early structure in the cosmic microwave background, these results can place strong constraints on cosmological parameters such as the average matter density and the Hubble constant" (wiki). In a redshift survey, when making it, it has 2 phases. One is the area of the sky observed by the telescope where you can discern galaxies from stars. The second one is the galaxies that have been observed by spectroscopy to measure the spectral line. In our case we are doing photometric redshift since it's a tad harder. You then compare the observed and laboratory wave lengths to get the redshift of the galaxies. The first Redshift survey was done in 1977 with about 2200 galaxies over 500 million light years away



1.1 calculating redshift with equations

If you want to calculate a redshift by hand in the most simple way you would need to know. If you know the velocity you can get a decent doppler redshift from this.

$$z = \frac{\Delta\lambda}{\lambda} = \sqrt{\frac{1 + \frac{v}{c}}{1 - \frac{v}{c}}} - 1 = \sqrt{\frac{1 + \beta}{1 - \beta}} - 1$$

where λ is understood to be $\lambda_{\text{emitted}} = \lambda_{\text{rest}}$, in the rest frame of the emitter.

$$1 + z = \frac{\lambda_{\text{observed}}}{\lambda_{\text{emitted}}} = \frac{R(t_0)}{R(t)} = \frac{1}{R(t)}$$

Calculating by hand isn't the worst if you are using this. But it's not the best. You won't get the most correct answers. There are other ways using calculus to determine the redshift but it would take another 20 pages just to talk about that. I will show a little bit of it below.

$$\begin{aligned} f(t_0) - f(t_1) &= f(t_0) + f'(t_0)\tau_0 + \frac{1}{2!}f''(t_0)\tau_0^2 \\ &+ \frac{1}{3!}f'''(t_0)\tau_0^3 + \dots - f(t_1) - f'(t_1)\Delta\tau_1 \\ &- \frac{1}{2!}f''(t_1)\tau_1^2 - \frac{1}{3!}f'''(t_1)\tau_1^3 - \dots \end{aligned}$$

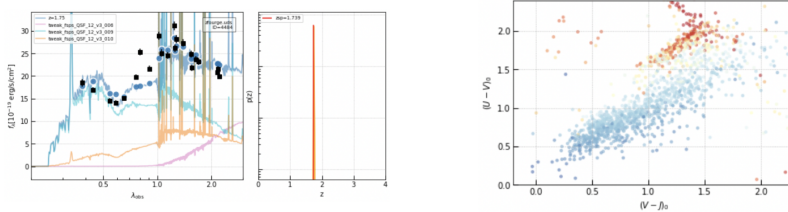
$$\begin{aligned} ds^2 &= c^2 dt^2 - R^2(t) \\ &\times \left(\frac{d\bar{r}^2}{1 - \kappa\bar{r}^2} + \bar{r}^2 d\theta^2 + \bar{r}^2 \sin^2 \theta d\phi^2 \right) \end{aligned}$$

$$\begin{aligned} \tau_0 &= -t_0 + \sqrt{t_0^2 + 2t_1\tau_1 + \tau_1^2} \\ &= -\frac{a}{R(t_0)} + \sqrt{\frac{a^2}{R^2(t_0)} + \frac{2a\tau_1}{R(t_1)} + \tau_1^2} \\ z &= \frac{\tau_0}{\tau_1} - 1 \\ &= -\frac{a}{\tau_1 R(t_0)} + \sqrt{\frac{a^2}{\tau_1^2 R^2(t_0)} + \frac{2a}{\tau_1 R(t_1)} + 1} - 1 \end{aligned}$$

There are about 40 more lines from scrip about this. But this calculation would just take too much time and is out of the scope of this project. The

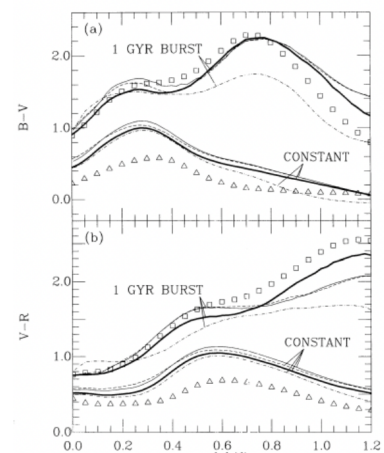
1.2 Eazy-py

The Photometric redshift was determined by using eazy-py. Eazy stands for; easy and accurate redshift(z) from Yale. This program was far from easy but we will discuss this later. This program finds photometric redshifts. It is used when spectroscopic redshifts are not there. It uses a template and a catalog of already determined spectroscopic redshifts. The way we did it was to just get the photometric data and not worry about a UBJ diagram or a brightness. The programmers themselves describe the program as “a photometric redshift code designed to produce high-quality redshifts for situations where complete spectroscopic calibration samples are not available.” it was made in the late 2000’s by Yale and then taken over by some people in 2015. The people who run it do have a PhD in astrophysics and are in a field related to it.



1.3 template fitting

Template fitting was something I never heard of until I looked into this program. I didn't know what it did or why it was used. Templates are used to model the spectra. The program has a lot of code to show how it works but it is 1000s of lines if I looked at it correctly and I didn't have enough time to look at it all to understand every step how it works. But it basically uses this template, throws all our data in it and calculates our redshift. In the image below, the code would mimic this.

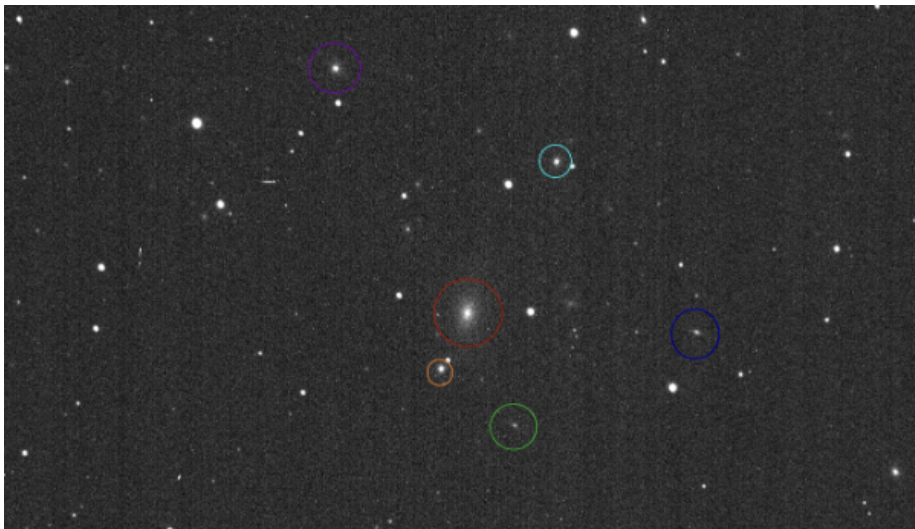


2 Methods

2.1 Data Collection

To start off the data collection we first have to start with the images. We requested images from lco telescopes. The Lco telescopes are about 14 inch in diameter are stationed in a few places around the world so we can get a good amount of sky coverage. Some of our galaxies include the cartwheel, Ngc 1650-1600-1-1661-1585 and then a few more we saw in the pictures that were given. The filters we used are SDSS R',G',U',I',z'.

We then threw each of the pictures into Astroart8 and calculated the magnatudes. We did that by finding about 3-5 reference stars, found their magnatudes online and then let it calculate our galaxies magnatudes. We thought we got decent data but had a 10,000 percent error when we ran the code. We redid it again and i believe we got around 50% error and couldnt do better.



2.2 The code

The code we used was supposed to be easy but it wasn't. Here I will go on and explain each part of the main code.

```
# environment installation for hosted notebooks
# (e.g., mybinder, GoogleCollab)
import os
import sys

orig_wd = os.getcwd()

try:
    import easy
    HAS_EASY = True
except:
    HAS_EASY = False

# mybinder
if ('jovyan' in orig_wd):
    if not HAS_EASY:
        print('Install on /home/jovyan')
        os.chdir('/home/jovyan')
        ! (sys.executable) -m pip install . -r requirements.txt
        os.chdir(orig_wd)

    try:
        import grizli
    except:
        ! (sys.executable) -m pip install cython
        ! (sys.executable) -m pip install git+https://github.com/gbrammer/grizli

    try:
        print('EASYCODE = ' + os.getenv('EASYCODE'))
    except:
        ! env EASYCODE=/home/jovyan/easy-photos/

# Google collab
if ('/content' in orig_wd):
    if not HAS_EASY:
        print('Install on /content (Google Collab)')
        os.chdir('/content')
        ! git clone https://github.com/gbrammer/easy-py.git --recurse-submodule
        os.chdir('/content/easy-py')
        ! (sys.executable) -m pip install . -r requirements.txt
        os.chdir(orig_wd)

    try:
        import grizli
    except:
        ! (sys.executable) -m pip install cython
        ! (sys.executable) -m pip install git+https://github.com/gbrammer/grizli

    try:
        print('EASYCODE = ' + os.getenv('EASYCODE'))
    except:
        ! env EASYCODE=/content/easy-py/easy-photos/

try:
    import astroquery
except:
    ! (sys.executable) -m pip install astroquery

try:
    import lxml
except ImportError:
    ! pip install lxml
```

Here on the left this code just loads every thing into the google colab folder. You import the easy program, throw it into my binder, install some other programs that hold some data and calculations in it to help us find out photometric redshift. Also downloads Grizli which is just a package that holds stuff like numpy, astropy and a few others. And then it imports some more code that I don't understand the best like lxml and astroquery.

Below is just checking if everything is actually downloaded.

```
# Module versions
import importlib
import sys
import time
print(time.ctime() + '\n')

print(sys.version + '\n')

for module in ['numpy', 'scipy', 'matplotlib', 'astropy', 'easy', 'prospect']:
    #print(module)
    mod = importlib.import_module(module)
    print('{0:>20} : {1}'.format(module, mod.__version__))
```

```
import os
import numpy as np
import matplotlib.pyplot as plt

import eazy

# Symlink templates & filters from the eazy-code repository
try:
    print('EAZYCODE = ' + os.getenv('EAZYCODE'))
except:
    pass

if not os.path.exists('templates'):
    eazy.symlink_eazy_inputs()
```

Next we have us linking our our template files and our template file. This caused us errors in the beginning. This should be simple but this small piece of code broke our code for a long while.

```
# quiet numpy/astropy warnings
import warnings
from astropy.utils.exceptions import AstropyWarning

np.seterr(all='ignore')
warnings.simplefilter('ignore', category=AstropyWarning)
```

This here just quiets all of our warnings. Not too much to say here.

```
params = {}
params['CATALOG_FILE'] = os.path.join(os.getenv('EAZYCODE'), 'inputs/hdfn_fs99_eazy.cat')

params['MAIN_OUTPUT_FILE'] = 'hdfn.eazypy'

# Galactic extinction
params['MW_EBV'] = 0.0103
params['CAT_HAS_EXTCORR'] = True

params['Z_STEP'] = 0.01
params['Z_MIN'] = 0.01
params['Z_MAX'] = 6.

params['PRIOR_ABZP'] = 25
params['PRIOR_FILTER'] = 28 # K
params['PRIOR_FILE'] = 'templates/prior_K_TAO.dat'

params['TEMPLATES_FILE'] = 'templates/fsps_full/tweak_fsps_QSF_l2_v3.param'

params['FIX_ZSPEC'] = False

params['IGM_SCALE_TAU'] = 1.0

translate_file = os.path.join(os.getenv('EAZYCODE'), 'inputs/zphot.translate')
```

#	id	F136	E136	F137	E137	F74	E74	F75	E75	F76	E76	z_spec
1	1.83860e-02	3.42664e-06	4.32430e-02	2.08067e-06	2.744300e-02	3.2149e-06	5.25000e-02	5.65002e-06	1.13979e-01	8.60562e-06	0.01582	
2	2.22900e-03	1.13543e-06	4.36000e-03	1.37891e-06	2.93500 e-03	9.6349e-07	4.93400e-03	1.44652e-06	1.21350e-02	3.10244e-06	0.01724	
3	5.96100e-03	1.83265e-06	5.41400e-03	1.55923e-06	4.059000e-03	1.1343e-06	6.93800e-03	1.73127e-06	1.52910e-02	3.57127e-06	0.01666	
4	9.12000e-03	2.67186e-06	1.25060e-02	2.56748e-06	8.091000e-03	1.7169e-06	1.51640e-02	2.78489e-06	2.97320e-02	5.18627e-06	0.03599	
5	2.41000e-03	1.38376e-06	4.34800e-03	1.45821e-06	2.604000e-03	9.4969e-07	4.36500e-03	1.42067e-06	9.35900e-03	2.73739e-06	0.04168	
6	1.88100e-03	1.25195e-06	2.76400e-03	1.16501e-06	1.640000e-03	7.6355e-07	3.22100e-03	1.21929e-06	6.46900e-03	2.25830e-06	0.03463	
7	9.16000e-04	9.53000e-07	1.51700e-03	8.88200e-07	9.260000e-04	6.0000e-07	2.00300e-03	9.92305e-07	3.21800e-03	1.60874e-06	-1.00000	
8	5.31000e-04	8.11000e-07	8.91000e-04	7.21000e-07	4.230000e-04	4.5900e-07	1.12500e-03	7.62262e-07	1.85500e-03	1.27085e-06	-1.00000	
9	9.99000e-04	9.80000e-07	3.87200e-03	1.37469e-06	1.959000e-03	8.2846e-07	4.18000e-03	1.38962e-06	8.06900e-03	2.53185e-06	0.03490	
10	8.44300e-03	3.74520e-06	4.60000e-03	2.09681e-06	9.137000e-03	2.5163e-06	1.81140e-02	4.20356e-06	1.54180e-02	5.166637e-06	0.02972	
11	1.11500e-03	1.65249e-06	8.85000e-04	1.08000e-06	4.010000e-03	1.6423e-06	6.25800e-03	2.37450e-06	6.78500e-03	3.37739e-06	0.01416	
12	2.04780e-02	5.98070e-06	6.72200e-03	2.53444e-06	9.818000e-03	2.6616e-06	1.83660e-02	4.23560e-06	2.96230e-02	7.39025e-06	0.01560	

Above Is the main chunk of the code for our purposes. It takes our file with the Fluxes and our corresponding errors that we calculated from our magnatudes. Here we see the default parameters. This is what gave us a 10,000% error. We had to lower the zmax and the zsteps to be

lower. If you wanted to use the default you would need a more varying amount of galaxies that are further away. It also can translate our filter names to the one they prefer but we did that manually.

```
self = easy.photoz.PhotoZ(param_file=None, translate_file=translate_file, zeropoint_file=None,
                           params=params, load_prior=True, load_products=False)
```

This part semi broke. We ran it once and worked and then ran it again and then it broke. This i believe just initializes part of the code that holds Photoz which does the calculations and all the comparisons

```
NITER = 3
NBIN = np.minimum(self.NOBJ//100, 180)

self.param.params['VERBOSITY'] = 1.
for iter in range(NITER):
    print('Iteration: ', iter)

    sn = self.fnu/self.efnu
    clip = (sn > 1).sum(axis=1) > 4 # Generally make this higher to ensure reasonable fits
    self.iterate_zp_templates(idx=self.idx[clip], update_templates=False,
                              update_zeropoints=True, iter=iter, n_proc=8,
                              save_templates=False, error_residuals=False,
                              NBIN=NBIN, get_spatial_offset=False)
```

This is supposed to give us zero point corrections but it wouldnt run for us at all, below is what it is supposed to be with its corresponding formula for it. A zero point correction that is used in photometry is the “magnitude of an object that produces 1 count per second on the detector. The zero point is used to calibrate a system to the standard magnitude system, as the flux detected from stars will vary from detector to detector”(wiki) .

$$M = -2.5 \log_{10} \left(\int_0^{\infty} F(\lambda) S d\lambda \right)$$

To get this data we got our magnatudes, converted them into fluxes and their corresponding errors and put them into a catalog file and threw it thorough our progam

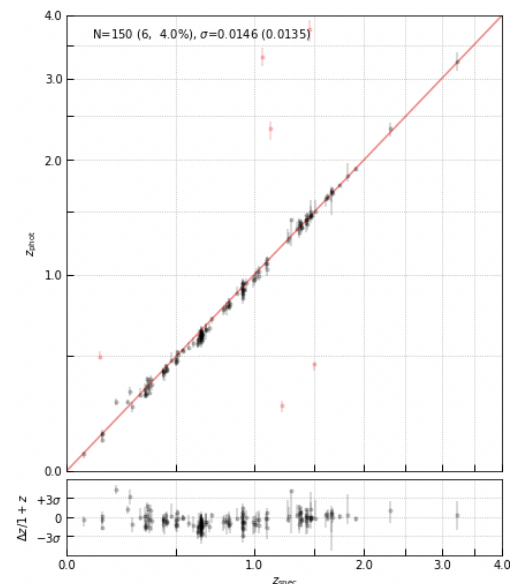
Magnitudes found using AstroArt and 1-5 reference stars depending on galaxy and filters.													
Magnitudes:													
Galaxy Identifier	NGC1600	NGC1603	NGC1601	NGC1650	MASX J04452168-1547268	2MASX J04451370-1553151	2MASX J04445318-1552381	LEDA 904935	NGC1	NGC2	NGC1661	6dFGS gJ044701.0-020847	NGC1585
B	13.414	15.705	14.637	14.175	15.62	15.899	16.67	17.263			14.259	16.457	13.297
V	12.37	14.861	14.626	13.717	14.864	15.356	16.007	16.585			14.803	16.592	14.391
g'	12.804	15.231	14.879	14.13	15.361	15.863	16.484	17.333	13.71	14.778	13.998	14.89	13.92
r'	12.098	14.667	14.297	13.448	14.8	15.13	15.684	16.272	13.145	14.141	13.255	14.409	13.24
i'	11.258	13.69	13.439	12.717	13.972	14.373	15.131	15.729	12.547	13.755	13.43	14.334	12.721
Corresponding Fluxes: (Jy)													
B	0.018386	0.002229	0.005961	0.00912	0.00241	0.001881	9.16E-04	5.31E-04			0.008443	0.001115	0.020478
V	0.043243	0.00436	0.005414	0.012506	0.004348	0.002764	0.001517	8.91E-04			0.0046	8.85E-04	0.006722
g'	0.027443	0.002935	0.004059	0.008091	0.002604	0.00164	9.26E-04	4.23E-04	0.011913	0.004455	0.009137	0.004018	0.009818
r'	0.05258	0.004934	0.006938	0.015164	0.004365	0.003221	0.002003	0.001125	0.020046	0.00801	0.018114	0.006258	0.018366
i'	0.113979	0.012135	0.015291	0.029732	0.009359	0.006469	0.003218	0.001855	0.034772	0.011429	0.015418	0.006705	0.029623

#	id	F136	E136	F137	E137	F74	E74	F75	E75	F76	E76	z_speed
1	1	1.8386e-02	3.4266e-06	4.3243e-02	2.0887e-06	2.744300e-02	3.2149e-06	5.25800e-02	5.65002e-06	1.13979e-01	8.60562e-06	0.01582
2	2	2.2290e-03	1.1354e-06	4.3600e-03	1.37891e-06	2.93500 e-03	9.6349e-07	4.9340e-03	1.44652e-06	1.21350e-02	3.10244e-06	0.01724
3	3	5.9610e-03	1.8326e-06	5.4140e-03	1.55923e-06	4.05900e-03	1.1343e-06	6.9380e-03	1.73127e-06	1.52910e-02	3.57127e-06	0.01666
4	4	9.1200e-03	2.6718e-06	1.2506e-02	2.56748e-06	8.09100e-03	1.7169e-06	1.51640e-02	2.78489e-06	2.97320e-02	5.18627e-06	0.03599
5	5	2.4100e-03	1.3837e-06	4.3480e-03	1.45821e-06	2.60400e-03	9.4969e-07	4.3650e-03	1.42067e-06	9.3590e-03	2.73739e-06	0.04169
6	6	1.8810e-03	1.2519e-06	2.7640e-03	1.16501e-06	1.64000e-03	7.6355e-07	3.2210e-03	1.21929e-06	6.4690e-03	2.25830e-06	0.03463
7	7	9.1600e-04	9.5300e-07	1.5170e-03	8.8820e-07	9.26000e-04	6.0000e-07	2.0030e-03	9.9230e-07	3.2180e-03	1.60874e-06	-1.0000
8	8	5.3100e-04	8.1100e-07	8.9100e-04	7.2100e-07	4.23000e-04	4.5900e-07	1.1250e-03	7.62262e-07	1.8550e-03	1.27085e-06	-1.0000
9	9	9.9900e-04	9.8000e-07	3.8720e-03	1.37469e-06	1.95900e-03	8.2846e-07	4.1800e-03	1.38962e-06	8.0690e-03	2.53185e-06	0.03496
10	10	8.4430e-03	3.7452e-06	4.6000e-03	2.09681e-06	9.13700e-03	2.5163e-06	1.81140e-02	4.20356e-06	1.54180e-02	5.166637e-06	0.02972
11	11	1.1150e-03	1.65249e-06	8.8500e-04	1.0800e-06	4.01800e-03	1.6423e-06	6.2580e-03	2.37458e-06	6.7050e-03	3.37739e-06	0.01416
12	12	2.04780e-02	5.98070e-06	6.7220e-03	2.53444e-06	9.81800e-03	2.6616e-06	1.83660e-02	4.23560e-06	2.96230e-02	7.39025e-06	0.01560

We did have an output file for our redshifts that told us our redshifts for each of the galaxies. For me it wouldnt output. I couldnt open the file and half the time the file wouldint even show up and i couldnt fiure out how to force it to. My partner did get it to open when he did it but i forgot to ask him to send me the file.

We got the survey we kinda wanted. If we had thousands of data points it would look more like the picture to the right. Where we had some outliers. To get this type of data we would have to have a better teselcope that makes better pictures.

I would have like to have portrayed this data in a better

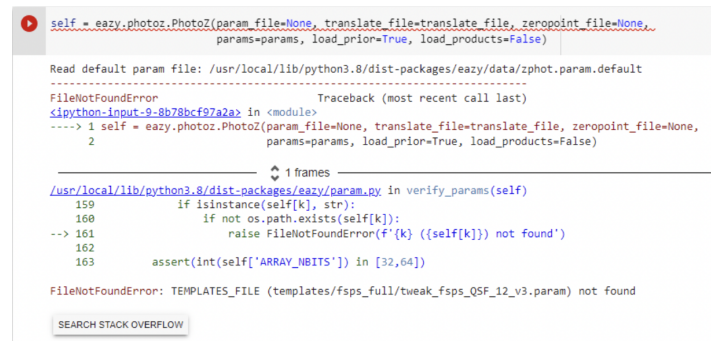


4 Discussion/conclusions

Due to the complications of the eazy program, we couldn't do more than we wanted to. It delayed us weeks, and we spent all of our time trying to fix it. I wanted to write a python program that would take the data of an image, use its pixel location of the predetermined galaxy and do an aperture to get the whole galaxy in frame for the information. Use this information to output the data automatically and compute those magnitudes to get fluxes and their corresponding errors. But we ran out of time before I could even start this step so we did it manually.

4.1 The errors of Eazy-py

About the end of october i tested the eazy code to make sure everything worked and it did. But a few weeks later, due to an update, the code broke and cut short my extra plans for the project. It would throw up file errors and io.attribute eros and once I fixed one issue another one came. It was exhausting because of all the time I put in trying to get this program to work.



```
self = eazy.photom.Photo2(param_file=None, translate_file=translate_file, zeropoint_file=None,
                           params=params, load_prior=True, load_products=False)

Read default param file: /usr/local/lib/python3.8/dist-packages/eazy/data/zphot.param.default
FileNotFoundError                                Traceback (most recent call last)
<ipython-input-9-8b78bcf97a2a> in <module>
----> 1 self = eazy.photom.Photo2(param_file=None, translate_file=translate_file, zeropoint_file=None,
      2                           params=params, load_prior=True, load_products=False)

1 frames
/usr/local/lib/python3.8/dist-packages/eazy/param.py in verify_params(self)
    159     if isinstance(self[k], str):
    160         if not os.path.exists(self[k]):
--> 161             raise FileNotFoundError(f'{k} ({self[k]}) not found')
    162
    163         assert(int(self['ARRAY_NBITS']) in [32,64])

FileNotFoundError: TEMPLATES_FILE (templates/fsp_full/tweak_fsp_QSF_12_v3.param) not found
```

This error right here came about early to mid november. When we finally got all of our data, i tried to re run the code that was working this is what happened. I spent hours each and every day trying to get the code to work. Every time i found a fix for one part another would break and i couldnt get any clean data out of it

4.2 conclusions

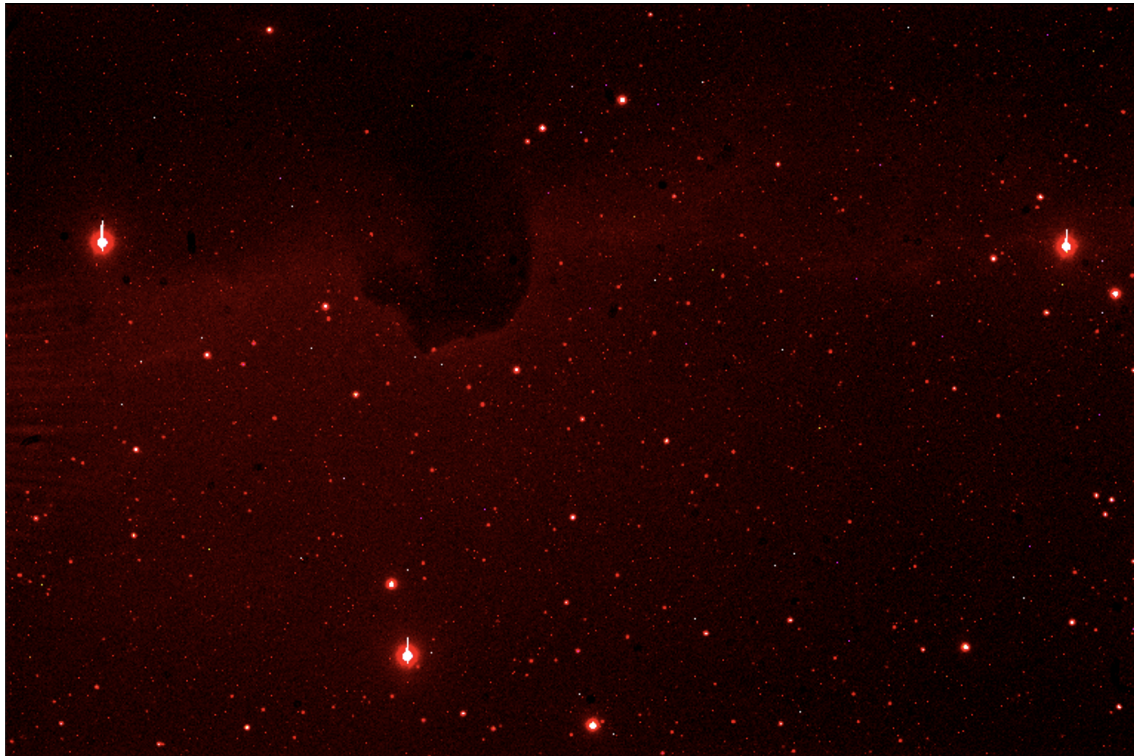
In the end of this project I was annoyed about all of the errors coming about, but I had fun learning code to help issues and learning more about redshifts. If i had to do this all again i probably would pick python coding that is more on my level than this. It was too much spending every single day trying to fix it while waiting for the Github creators to respond. But i do give it to them. When i reported it they fixed it but then said there wasnt a problem. It was little weird. What would i do to get better data?

- Use a better telescope
- Use a program to read all of the magnitudes more accurately.
- Use a more simple program so it doesnt break down quick
- Ask for more help earlier with the code. I thought I could fix it earlier but i couldnt.

I had more plans but these errors were crazy. I wish i could have done more with the code but i think we did the best we can do for the redshift survey.

5 horsehead nebula

This was made using 3 different filter bands. I think it was r g and b. It was made about mid october with lco data that the Ta said we can use. I tried messing with this photo but I couldn't make it less red for some reason. But using astroart I made this photo. I think this was part of other data that had different photos you can make. After making this photo, it makes me want to set up my telescope and see if I can recreate this on my own. But I have a dobsonian so it's a little harder to do so. I think i will help my dad with this since he always wanted to make his own photos with his telescope.



References

- Sherman, S., Jogee, S., Florez, J., Stevans, M. L., Kawinwanichakij, L., Wold, I., Finkelstein, S. L., Papovich, C., Acquaviva, V., Ciardullo, R., Gronwall, C., & Escalante, Z. (2019, November 15). *Exploring the high-mass end of the stellar mass function of star forming galaxies at Cosmic Noon*. arXiv.org. Retrieved December 8, 2022, from <https://arxiv.org/abs/1911.06829>
- Nelson, E. J., Suess, K. A., Bezanson, R., Price, S. H., Dokkum, P. van, Leja, J., Whitaker, B. W. K. E., Labbé, I., Barrufet, L., Brammer, G., Eisenstein, D. J., Heintz, K. E., Johnson, B. D., Mathews, E., Miller, T. B., Oesch, P. A., Sandles, L., Setton, D. J., Speagle, J. S., ... Weaver, H. Ü. J. (n.d.). *Jwst reveals a population of ultra-red, flattened disk galaxies at 2*. *JWST reveals a population of ultra-red, flattened disk galaxies at 2*
- ArXiv:2002.07189v1 [astro-ph.GA] 17 Feb 2020*. (n.d.). Retrieved December 9, 2022, from <https://arxiv.org/pdf/2002.07189.pdf>
- Hou¹, S.-J., Du², S., Liu⁴, T., Mu⁵, H.-J., Xu², R.-X., <https://orcid.org/0000-0001-5247-5559>, S. D., <https://orcid.org/0000-0001-8678-6291>, T. L., & <https://orcid.org/0000-0001-6589-2220>, H.-J. M. (2021, November 24). *IOPscience*. The Astrophysical Journal. Retrieved December 8, 2022, from <https://iopscience.iop.org/article/10.3847/1538-4357/ac2c74>

Wikimedia Foundation. (2022, December 1). *Redshift*. Wikipedia. Retrieved December 8, 2022, from

<https://en.wikipedia.org/wiki/Redshift#:~:text=In%201868%2C%20British%20astronomer%20William,0.1%20%C3%85%20in%20the%20red.>

Glatt, J. (n.d.). *Calculating redshift via astronomical spectroscopy*.

DigitalCommons@USU. Retrieved December 8, 2022, from https://digitalcommons.usu.edu/phys_capstoneproject/66/

Wikimedia Foundation. (2022, May 18). *Redshift survey*. Wikipedia. Retrieved December 8, 2022, from https://en.wikipedia.org/wiki/Redshift_survey

Gbrammer. (n.d.). *Gbrammer/eazy-py: Pythonic Photometric Redshift Tools based on Eazy*.

GitHub. Retrieved December 8, 2022, from <https://github.com/gbrammer/eazy-py>