ASTRO 461 Sp23 MDM OBSERVING PROPOSAL

Due: Friday, May 12, 5:00 PM

TITLE: Investigating the Reliability of Photometric Redshifts

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ABSTRACT:

Redshift is key in determining the distance of galaxies where it's unreasonable to try to observe Cepheids. Since supernovae are not common enough such that every galaxy has at least one observable supernova, we are often left with using relationships like the Tully-Fisher relation, spectroscopic redshifts, and photometric redshifts. Spectroscopic redshifts provide the most accurate distance calculations with the smallest uncertainties, but spectroscopic data is significantly more expensive than photometric data (spatial/regular imagery data). We will compare the photometric redshift to the spectroscopic redshift of 6 galaxies within a range of $0.022 < z < 0.400$ to determine the viability of using photometric redshift values in further research. We will compare the uncertainties from both the spectroscopic and photometric redshifts and use both to calculate the Hubble constant, H_0, to give a real world example of the effect that the increased photometric redshift uncertainty has on research.

1.3-m + B4K CCD	Request	2.4-m + CCDS	Request
Filters	ugri	**Wavelength range**	6000-7000Å
Number of hours	~6	**Number of hours**	~8
Time range	19:00 - 4:00	**Time range**	19:00 - 4:00

Notes about observing setup:

<u>SCIENTIFIC MOTIVATION</u> *Give background and explain why your project is important. (Limit to 1 page, excluding any figures.)*

Redshift is an integral consequence of the Big Bang and the expansion of the Universe. We use spectroscopic data to get very tight constraints on the redshift of distant objects, but spectroscopic data is orders of magnitude more expensive than spatial imagery data. However, spatial imagery data can also be used in finding the photometric redshift of objects at the cost of accuracy. This makes spatial data significantly more versatile than spectroscopic data and thus more desirable.

We know that photometric redshifts are less accurate than spectroscopic redshifts, but we don't know how this uncertainty directly translates to real world uncertainties. We can compare spectroscopic redshifts to photometric redshifts of the same galaxies to better understand the reliability of photometric redshifts. By using both our photometric redshifts and spectroscopic redshifts to calculate the Hubble constant, we can determine the reliability of using photometric redshifts for further research. The MDM Observatory is perfect for this project because it gives access to both spectroscopic observations and spatial image observations.

<u>TECHNICAL AND SCIENTIFIC FEASIBILITY</u> *Describe how your data will address your science goals and show that the instrument setup and time request will yield the necessary data. (Limit to 1 page, excluding any figures.)*

The main feature of this project is our intention to highlight the cheap resource costs of photometric redshift techniques and see how these still hold up in accuracy compared to the more precise and accurate spectroscopic redshift methods. To be able to show off the effectiveness of this method, we will thus need spatial imagery data for our sample of 6 galaxies in order to get the fluxes across each of the SDSS ugri bandpasses. Using this data, it is possible to locate the Balmer break in our galactic fluxes which produces a noticeable change in flux, depending on its redshift. Thus if we can find the location of the Balmer break using these changes in flux across the bandpasses, we can find the photometric redshift for our galaxy, which is exactly what we need.

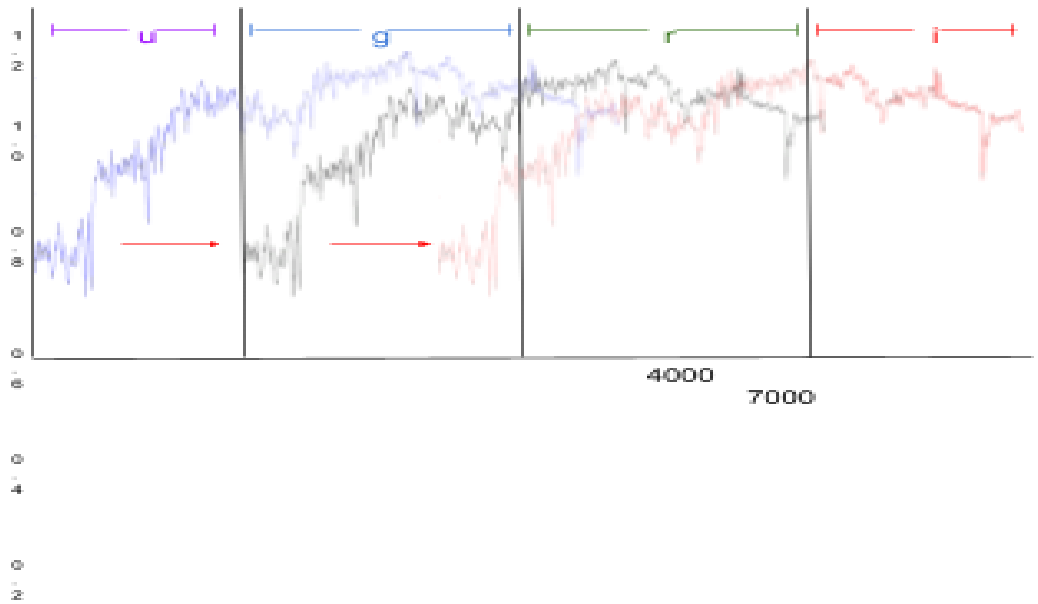


Figure 1: Above we have a diagram highlighting the spectral energy distribution of the type Sa galaxy NGC 2775. We have overplotted multiple versions of this distribution to highlight the shift this spectrum will undergo based on its redshift. These distributions are color coded to match their relative shifts in wavelength. We also have overplotted the locations of the SDSS ugri filters.

Getting the exact spectral location of the Balmer break is something that can be done with the use of some template fitting methods. For our analysis, we will use standard template fitting routines provided by the EAZY photo-z python package. Using template fitting methods we can find a more exact wavelength location for this break within the bandpass filter we estimate the break to be in.

Because we are attempting to justify the accuracy as well as the inexpensiveness of this method of redshift calculation, we also will need a point of reference for the fitted redshift values we find using our photometric data. This means we will need some comparison with the more accepted spectroscopic redshift calculation method for our sample of galaxies as well.

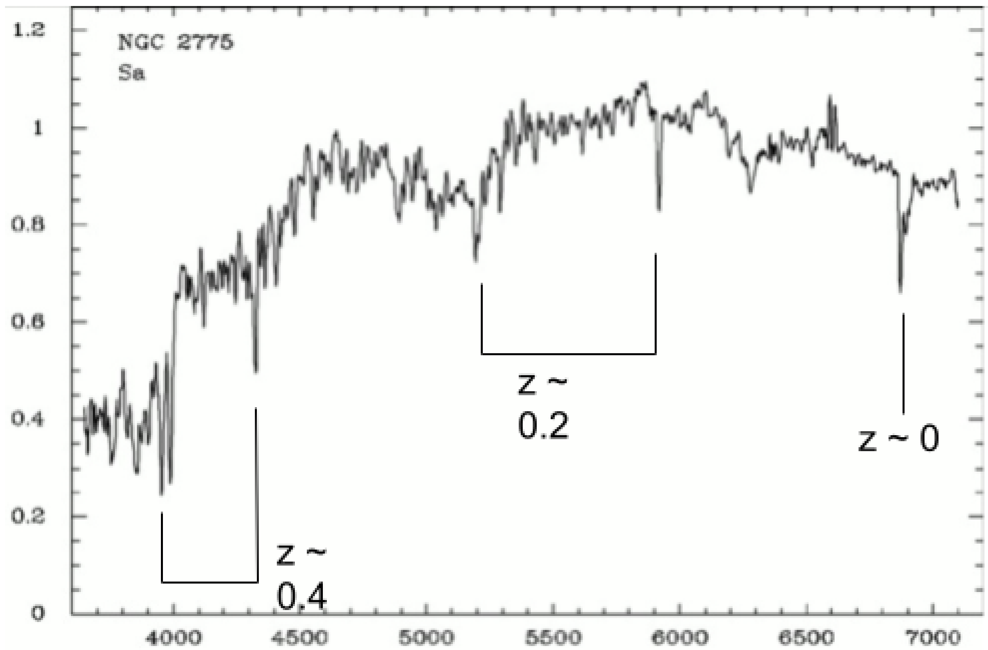
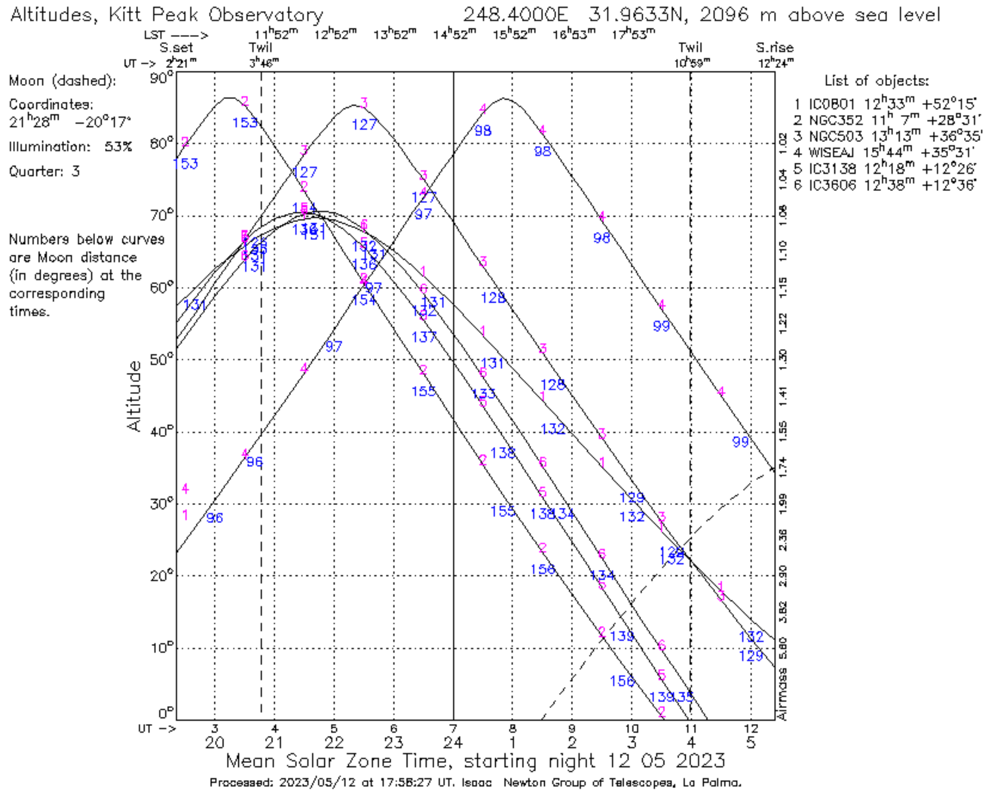


Figure 2: Above is plotted a galactic spectra for NGC 2775, a type Sa galaxy (Kennicutt, 1992). On top of this spectrum we have marked the locations of the spectral features that we will use to find our spectroscopic redshifts and the approximate redshifts that will shift these features into our spectral wavelength range.

For our spectroscopic analysis, we have found a series of spectral features that we can use to showcase the spectroscopic redshift of the galaxies in our sample, highlighted in Figure 1. We have calculated that all these features will land within the 6000 - 7000 Å range based on their expected redshifts, and thus we will be able to observe them all within our requested wavelength range.

Using all of this data, we will be able to make comparisons on the accuracy of our photometric redshift data to that we have measured from the spectroscopic data as well. With these redshifts calculated, we can get the recessional velocity for each galaxy in our sample. This, combined with a known galactic distance measurement calculated from a method other than redshift, means we can get an estimate for Hubble's constant, H_0.


Altitudes, Kitt Peak Observatory
248.4000E 31.9633N, 2096 m above sea level
LST --->
11h52m 12h52m 13h52m 14h52m 15h52m 16h53m 17h53m
S.set
Twil
Twil
S.rise
UT -> 2h21m
3h46m
10h59m
12h24m
Moon (dashed):
Coordinates:
21h28m -20°17'
Illumination: 53%
Quarter: 3
Numbers below curves are Moon distance (in degrees) at the corresponding times.
Altitude
Airmass
List of objects:
1 IC0801 12h33m +52°15'
2 NGC352 11h 7m +28°31'
3 NGC503 13h13m +36°35'
4 WISEAJ 15h44m +35°31'
5 IC3138 12h18m +12°26'
6 IC3606 12h38m +12°36'
UT ->
Mean Solar Zone Time, starting night 12 05 2023
Processed: 2023/05/12 at 17:58:27 UT. Isaac Newton Group of Telescopes, La Palma.

TARGET LIST

Priority	Object	RA	Dec	*V* mag	z	H-type
1	NGC5033	13 13 27.53	+36 35 37.14	12.03	0.029	Sa
2	IC3606	12 38 25.09	+12 36 38.27	15.79	0.110	E
3	WISEA J154448.09+353223.8	15 44 53.75	+35 31 43.63	15.79	0.400	?
4	IC0801	12 33 44.95	+52 15 17.28	13.70	0.022	Sa
5	IC3138	12 18 56.16	+12 26 43.00	15.80	0.093	E
6	NGC3527	11 07 18.18	+28 31 39.98	13.90	0.033	Sa

REFERENCES

Binney, J., & Merrifield, M.. (1998), Galactic Astronomy. gaas.book. https://ui.adsabs.harvard.edu/abs/1998gaas.book.....B.

Brammer, G. B., van Dokkum, P. G., & Coppi, P.. (2008), EAZY: A Fast, Public Photometric Redshift Code. ApJ. 686, 1503. https://ui.adsabs.harvard.edu/abs/2008ApJ...686.1503B.

Kennicutt, R. C.. (1992), A Spectrophotometric Atlas of Galaxies. ApJS. 79, 255. https://ui.adsabs.harvard.edu/abs/1992ApJS...79..255K.

Verga, M. (2023), PyOngc. Github. https://github.com/mattiaverga/PyOngc.