

Supernova Cosmology: Mid-Term Report

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So Far

Our project is centred around supernovae, for our experiment we have been attempting to collect enough magnitude data over the past few weeks to generate some light curves to show magnitude as a function of time. We have been aiming to try and see the characteristic shapes that are associated with the varying types of SN. Having collected this, we then want to apply different templates to our data and see how it fits. Calculating the χ^2 statistic where possible to quantify the quality of our data.

To perform our data collection we have been using the telescopes in Durham (on the Physics Department's Roof) and we have used the telescope in La Palma. When there has been an opportunity for us to observe in Durham we have always aimed to use Far-East-16 (when the exoplanets group are not struggling to collect data). This is because as our objects are so faint (they often have a magnitude of around $\sim 15 - 18$), we require a telescope which can collect as much as light as possible, the 16-inch provides us with a way to do so. But, we can also use East-14 and West-14, we just need to ensure that we use a longer exposure time from 120s to ensure we can collect as much light as possible.

Once we had collected this data, we then required to perform the correct data analysis on it. Our sessions generally involve the following:

- We retrieve and copy the data from the previous night(s) observations from the remote server.
- We then perform stacking using the `d_stack` script to remove any noise such as cosmic rays, and also to 'increase' the number of counts we get from an object.
- The software package GAIA is used as a tool to aid us in our photometry:
 - The image is orientated so that it is comparable to discovery image that we have from the Rochester database.
 - A search is then done to match any known objects in the image to UCAC4, the U.S. Naval Observatory catalogue of objects. This is done so that we can identify our object more easily, along with using the RA and Dec from the SNe. We also found where our comparison stars were, but we eventually learned the location of these after analysing the data multiple times.
 - Using the Aperture Photometry tools on the software, the results in data counts were found for our calibration/comparison stars, and for our SNe as well.
 - Once this had been noted down, a custom Python script would be ran calculating our magnitudes and errors using the following equations,

$$m = z - 2.5 \log_{10} C, \quad (1)$$

$$\delta m = 2.5 \log_{10} \left(1 + \frac{1}{\sqrt{C}} \right), \quad (2)$$

where m the magnitude of the objects, z is our zero-point (found by using our calibration stars), and C is the number of counts.

The above method has only been employed for a week, we had been using an incorrect one previously which would produce magnitudes which did not seem reasonable at all, due to the fact that the uncertainties would be very small.

Using our old method of to calculate magnitudes using ratios, for our main object *2017hhz*, for data from the 20th October 2017, the V band magnitude was found to be 16.25 ± 0.01 , and B band was 15.82 ± 0.01 . Using the method briefly detailed above, for this same set of data we have now found that the magnitudes for V and B band are respectively, 17.1 ± 0.1 and 16.9 ± 0.1 . The latter values seem more reasonable as using our instrumentation we cannot achieve that high level of precision.

We must also note that the above method is for finding the differential magnitudes, or the instrumental magnitudes. What would be of more particular interest would be the absolute magnitudes. This can be found out through calculating the 'actual' zero point of the image and then using the magnitudes tool on GAIA to process the calibration stars and the SNe.

Having both sets of data we can then compare and calculate the differences between them.

Plan for the remainder of the project

As we move onto the final half of our project, the main question that we would like to ask is: to what accuracy can we produce these light curves to and whether or not it would produce a valid value for Hubble's Constant, H_0 ?

Our masterplan for this stage of the project is as follows,

- To continue to perform relative photometry on our SNe candidates
- To perform model/template fittings to our supernovae
- To then perform absolute photometry on our SNe by finding the zero points
- To continue observing our candidates: 2017hhz, AT2017hhq, 2017hou, and AT2017gvb. (from Durham and from La Palma)
- To find potential viewing candidates from the SN database on Rochester and ASAS-SN

- To flat-field our images
- To use our data from our Type Ia supernovae to calculate a value for H_0
- To try and perform a galaxy subtraction from one of sets of data to leave just the SNe in view

There is still a lot of work to complete and analysis to perform, but with good time management and with planning it will be completed. Also it all depends on the weather.

Appendix A - Objects Log

A list of the objects that were chosen to be observed, and then the subsequent notes on them. Not all objects were chosen to be observed for an extended period, the ones noted were observed for a couple of nights to ensure suitability. The subsequent observation logs can be found in Appendix B.

Object	RA	Dec	Magnitude	First Discovered	Type	Notes
*ASASSN-17mz	23:56:21.82	32:27:24.08	14.6	2017/09/30.500	Ia	Too close to galactic nucleus, cannot see
*AT2017hld	22:18:22.849	34:45:08.46	16.1	2017/10/17.339	CV	Cataclysmic Variable, stopped observing
*AT2017hky	11:23:30.514	63:21:59.43	16.2	2017/10/16.640	II	Not viewable from Durham or La Palma
2017hhz	01:44:16.75	12:15:18.00	16.83	2017/10/16.140	Ia	A measured redshift, $z = 0.0392$
AT2017gvb	08:04:42.34	61:31:41.50	17.33	2017/09/26.59	unk	-
*ASASSN-17nb	07:27:37.32	35:36:28.30	17.31	2017/09/25.59	II	Object is dwarfed by brightness of the galaxy
2017hle	01:07:36.060	32:24:30	18.0	2017/10/18.684	Ia-91bg	-
2017hou	04:09:02.140	-01:09:36.40	17.9	2017/10/24.370	Ia	Viewable from La Palma
*AT2017hmw	01:07:16.570	31:25:28.88	17.2	2017/10/19.415	CV	Cataclysmic Variable
2017hpa	04:39:50.750	07:03:54.90	17.9	2017/10/15.346	Ia	Viewable from La Palma
*AT2017hnm	01:42:03.24	42:31:08.50	16.69	2017/10/23.44	unk	Another star in the image dwarfs the SN in brightness
AT2017hpm	08:04:15.100	-00:03:58.03	16.4	2017/10/26.290	unk	-
*AT2017hqa	01:08:59.160	32:38:04.10	17.3	2017/10/26.740	unk	Unobservable, too close to galactic centre
2017hqc	23:23:08.210	10:38:54.63	18.0	2017/10/27.490	Ia	-
*AT2017hrr	11:29:06.490	-08:59:18.56	15.4	2017/10/30.607	unk	Cannot view from Durham or La Palma
*AT2017hhq	00:42:50.230	41:15:27.10	17.7	2017/10/30.599	NV	A nova close to M31
AT2017htb	22:09:38.520	17:39:39.56	15.7	2017/11/02.190	unk	-

TABLE I: Objects that we chose to observe and notes on them. RA is the Right Ascension, given in units of hours : arcminutes : arcseconds. Dec is the Declination, degrees : minutes : seconds. The stated magnitude is the initial magnitude that the object was discovered at (or stated otherwise in the notes), it's units are (??).

Appendix B - Observation Logs

Given below are all the observations and details of those observations made between x and y. With the information provided in the column, **Exposures**, the filters used and the number of exposures taken in the given exposure time. CHANGE TIMES FOR EARLY PT5M OBJECTS

Date	Object	Time	Exposures	Conditions	Notes
20/10/17	2017hhz	20:42:54 to 23:43:21	B, 4 in 60s V, 12 in 60s	Cloudy	pt5m: Images were cloudy in the B-band, seeing was not high
	ASASSN-17nb	20:42:54 to 23:43:21	B, 4 in 60s V, 12 in 60s	Clear?	pt5m: images have a low seeing
21/10/17	-	-	-	Cloudy	<i>No observations, weather not sufficient in Durham or La Palma</i>
22/10/17	2017hhz	20:42:54 to 23:43:21	B, 4 in 60s V, 12 in 60s	Cloudy	pt5m: Images were cloudy in the B-band, seeing was not high
	ASASSN-17nb	20:42:54 to 23:43:21	B, 4 in 60s V, 12 in 60s	Clear?	pt5m: images have a low seeing
	AT2017hmw	20:42:54 to 23:43:21	B, 4 in 60s V, 12 in 60s	Clear?	pt5m: images have a low seeing
23/10/17	2017hhz	20:42:54 to 23:43:21	B, 4 in 60s V, 12 in 60s	Clear?	pt5m: Images were cloudy in the B-band, seeing was not high
24/10/17	2017hhz	20:42:54 to 23:43:21	B, 4 in 60s V, 12 in 60s	Clear?	pt5m: Images were cloudy in the B-band, seeing was not high
25/10/17	-	-	-	Cloudy	FE16/W14: <i>No observations, too cloudy for observations in Durham</i>
26/10/17	2017hhz	21:18:00 to 21:25:31	B, 4 in 60s V, 4 in 60s	Clear	FE16: Seeing good, images not bad
	2017hle	-	-	Cloudy	pt5m: images have a low seeing

TABLE II: Observing logs for the entire observation period for our experiment.