Data Exercise Notes

Saksham Kaushal

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1 Photometry

1. **Do you understand what is changing?** – using *autocut, colour map, intensity map,* and *colour bar.*
2. **How can you determine which object is the nova?**

   Using multiple images. Nova are transients with their luminosities fading over time, typically few days/weeks. So, looking out for stars with luminosities fading over time would help us determine which object is a nova. $\alpha = 00:44:41.05, \delta = 40:08:36.00$
3. **Header contents, position and pixel information**

file	DATE-OBS	MJD	EXPTIME	AIRMASS	x-axis span
phot_00.fits	2016/07/16 01:54:04.626	57585.079220	120	1.7258910	1049–1061
phot_01.fits	2016/07/17 01:57:55.414	57586.081891	120	1.6665240	1049–1061
phot_02.fits	2016/07/18 01:43:20.318	57587.071763	120	1.7491860	1049–1061
phot_03.fits	2016/07/19 01:36:39.439	57588.067123	120	1.7721150	1050–1061
phot_04.fits	2016/07/22 02:34:57.627	57591.107611	120	1.3530670	1052–1058
phot_05.fits	2016/07/25 01:29:33.555	57594.062194	120	1.6443790	1053–1058
phot_06.fits	2016/07/27 01:35:03.477	57596.066012	120	1.5562500	1052–1058
phot_07.fits	2016/08/03 03:15:00.354	57603.135421	120	1.1115970	1053–1058
phot_08.fits	2016/08/09 01:19:45.090	57609.055383	120	1.3717510	1050–1060
phot_09.fits	2016/08/17 01:26:10.686	57617.059846	120	1.2355820	1053–1058
phot_10.fits	2016/08/19 02:09:48.268	57619.090142	120	1.1156090	1053–1058
phot_11.fits	2016/08/21 02:53:30.765	57621.120495	120	1.0482370	—
phot_12.fits	2016/08/27 01:30:12.240	57627.062642	120	1.1306350	1053–1057
phot_13.fits	2016/08/29 03:01:21.059	57629.125938	120	1.0244450	1054–1057
phot_14.fits	2016/09/06 02:28:01.479	57637.102795	120	1.0250930	1054–1057
phot_15.fits	2016/09/13 23:52:30.836	57644.994801	120	1.1904340	1054–1056
phot_16.fits	2016/09/24 02:27:20.058	57655.102315	300	1.0329910	1053–1056
phot_17.fits	2016/09/28 02:53:32.834	57659.120519	300	1.0706010	1054–1056

   GAIN = 1.62, Position = (1055,978) for all entries.
4. **Are the number of pixels containing light from the nova (i.e. the point spread function or PSF) the same in every image? What two effects could be changing this?**

   No. Change in auto-cut value and variations in brightness of background or nova can change the viewed psf.
5. **Why is it important to do this?** – enter *exposure time* and *gain* for each observation.

   Image of a faint object captured over long exposure time may be brighter than the image of a bright object captured over smaller exposure time. Similarly, high gain would require more photons per data unit. Therefore, for different values of gain too, our perception of bright and faint objects may vary from one image to another. Hence, it is important to account for exposure time and gain for each image.
6. **Why would it be undesirable to use an aperture that is either too small or too large?**

   A very small aperture would lead to loss of signal by discarding useful signal. A large aperture would include a lot of noise. Hence in both cases, signal to noise ratio is decreased, although in different ways. An optimal aperture considers all the signal while discarding maximum possible noise. In aperture photometry, the outer annulus is used to account for calculate average noise value. This value is subtracted from the aperture signal to obtain true signal. If the aperture contains noise (very large aperture) or discards signal (very small aperture), the calculated value will account for smaller than true overall value of signal or signal to noise ratio.
7. **Signal to noise ratios for different apertures. How do you decide which aperture is optimal?**

radius	magnitude	mag error	signal	noise	SNR
6.0	-8.02378	0.00512	3656.2	1620.0	2.257
10.4	-8.13224	0.00738	3629.6	1790.2	2.0275
15.5	-8.15562	0.01047	3627.2	1829.1	1.983
26.5	-8.16615	0.01745	3626.2	1847.0	1.963

   Optimal is systematically decided using data count results instead of magnitude results. A rough estimate for better understanding can be performed using table above.
8. **Do the results you have obtained, by varying the aperture size, vary randomly as you might expect with measurement error?**

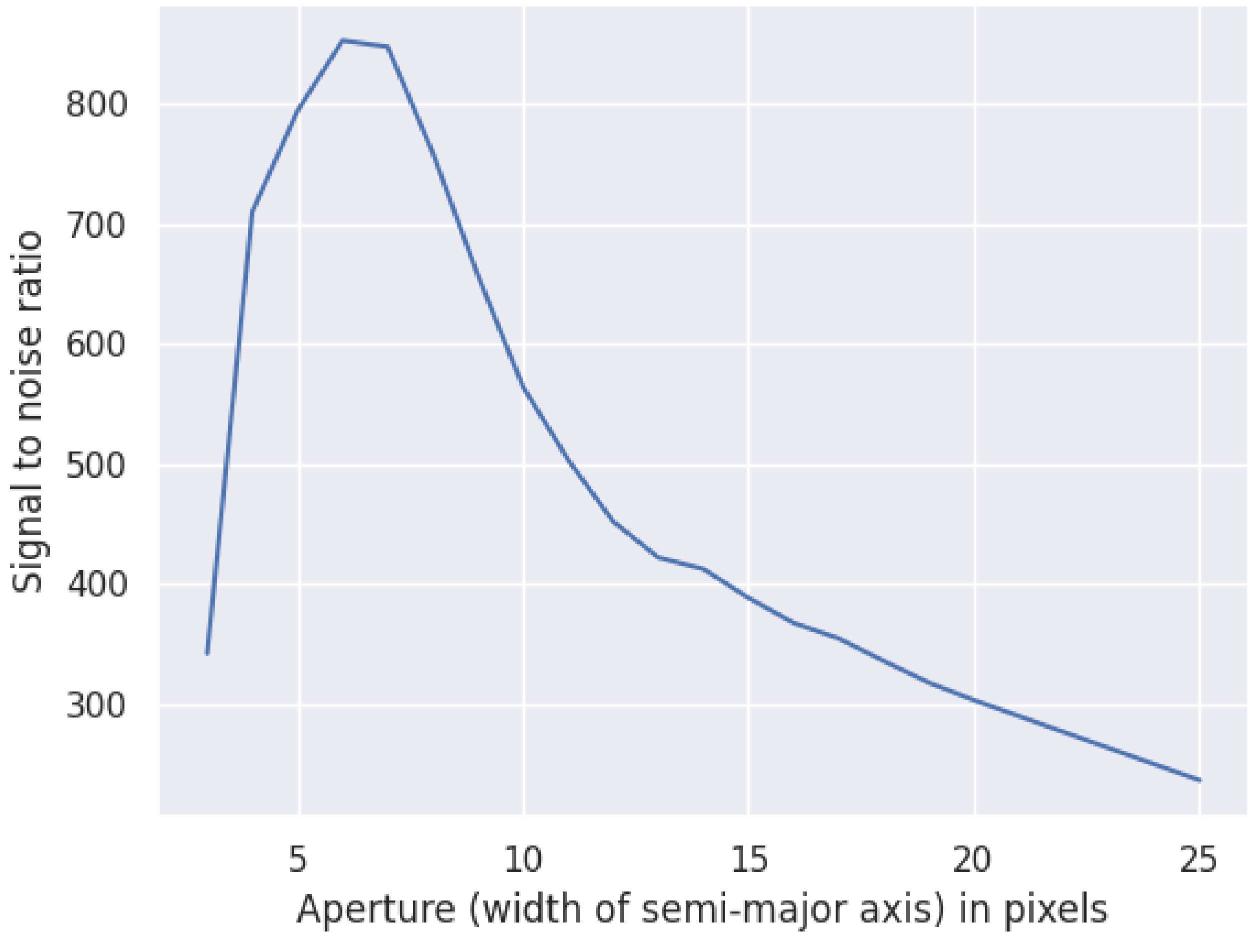
   No. Results vary in a well defined manner according to the reasons stated above. The errors are not random, and instead depend upon the radius of the aperture. Both small and large apertures are inefficient and an optimum aperture lies in between that range.
9. **determine the optimal aperture size.**

   $r_a = 1.5$ and $r_b = 2.0$. SNR = [342.527,710.071,794.189,852.760,847.537,759.236, 657.519, 564.448, 503.706, 452.286, 422.322, 412.725, 388.763, 367.845, 354.948, 336.155, 318.092, 303.514]
10. **What would be the effect of changing the aperture size between measurements within the same image?**

    Would give inconsistent values of magnitudes for different objects.
11. **Optimal apertures for all images.**
12. **Does the optimal aperture size vary between the images? If so, what causes this?**

    Optimal aperture size varies for different images depending upon atmospheric seeing (or the background noise), exposure time, object brightness, etc.

aperture (semi-major axis)	mean counts	error in counts	SNR
3.0	36.784	0.10739	342.527
4.0	26.835	0.037792	710.071
5.0	19.433	0.024469	794.189
6.0	14.398	0.016884	852.760
7.0	11.029	0.013013	847.537
8.0	8.6644	0.011412	759.236
9.0	6.9651	0.010593	657.519
10.0	5.7077	0.010112	564.448
11.0	4.7566	0.0094432	503.706
12.0	4.0395	0.0089313	452.286
13.0	3.4646	0.0082037	422.322
14.0	2.9852	0.0072329	412.725
15.0	2.6030	0.0066956	388.763
16.0	2.2916	0.0062298	367.845
17.0	2.0352	0.0057338	354.948
18.0	1.8190	0.0054112	336.155
19.0	1.6286	0.0051199	318.092
20.0	1.4728	0.0048525	303.514
25.0	0.94289	0.0039804	236.883



13. **Why does this approach work? What problems might be associated with this method?** – using secondary stars for photometry.

    We need to consider only the stars which have been observed to remain static (i.e. not a variable star) over extremely long periods, so that its low photometric uncertainty can be considered reliable for calibration. If such a non-variable star lies in our field of view while observing the science object, the photometry of that object can be calibrated using the nearby secondary standard. Even if the atmospheric conditions are not very favourable, photometry can still be performed if we can safely assume that the extent of unfavourability of conditions is similar for both the objects, which is a reasonable assumption for nearby secondary standards. Secondly, widely separated secondary stars in the field of view can be used to estimate variability in atmospheric extinction across field of view. For faint events, exposure times are long and many of the primary standards appear saturated. Dimmer secondary stars therefore are more helpful in these cases.

14. **How can we determine which of the PS1 stars might be suitable to use?**

    Vicinity to the nova and comparable brightness. Vicinity would lead to correlating atmospheric extinction values, which would be roughly similar for all, and therefore, easily accounted for. Similar brightness or *spread* of stars would aid the use of same aperture for all standard stars and nova in the image. Also, every secondary star selected should be properly resolved in the image.

15. **Secondary stars**

    ID = [11,2,6,30,10]

16. **Photometry of nova and stars**

17. **Catalog entries SDSS conversions.**

file	aperture
00	7.0
01	6.5
02	5.5
03	5.4
04	4.9
05	4.9
06	8.0
07	4.4
08	7.5
09	4.6
10	3.1
11	4.4
12	3.6
13	2.5
14	2.3
15	4.2
16	3.3
17	2.9

image	nova	star 1 (1079,741)	star 2 (985,665)	star 3 (740,1205)	star 4 (392,1111)	star 5 (1275,1305)
00	8.06917,0.00554	-8.79153,0.00311	-8.19322,0.00501	-8.43167,0.00413	-6.81993,0.01639	-9.23457,0.00222
01	-8.11788,0.00477	-9.08614,0.00228	-8.49188,0.00355	-8.72659,0.00296	-7.11721,0.01104	-9.52156,0.00168
02	-7.78778,0.00655	-8.94943,0.00261	-8.34755,0.00414	-8.58463,0.00344	-6.95411,0.01345	-9.37925,0.00192
03	-7.7492,0.00711	-9.06624,0.00248	-8.47205,0.00392	-8.70987,0.00324	-7.09267,0.1257	-9.50961,0.0018
04	-7.01378,0.01582	-8.67234,0.00379	-8.0789,0.00621	-8.32961,0.00501	-6.72892,0.02037	-9.10936,0.00268
05	-6.7958,0.01559	-8.76096,0.00302	-8.16958,0.00477	-8.41133,0.00394	-6.80057,0.01552	-9.20142,0.00218
06	-6.22505,0.02621	-8.4437,0.0039	-7.86253,0.00628	-8.09466,0.00516	-6.45922,0.02131	-8.86995,0.00281
07	-6.00348,0.00998	-8.78424,0.00191	-8.19902,0.00259	-8.44785,0.00226	-6.83937,0.00566	-9.23819,0.00152
08	-5.19026,0.03097	-8.44701,0.00266	-786816,0.00381	-8.10531,0.00328	-6.48753,0.01046	-8.89045,0.00205
09	-5.31643,0.04588	-9.07027,0.0021	-8.47533,0.00321	-8.72066,0.00267	-7.124,0.00931	-9.51246,0.00158
10	-4.58417,0.07163	-8.58765,0.00271	-8.00687,0.00403	-8.26852,0.00333	-6.63258,0.01166	-9.03455,0.00204
11	0.351068,0.28434	-7.62915,0.00734	-7.06545,0.01171	-7.29312,0.00969	-5.63848,0.04075	-8.08902,0.00511
12	-4.08713,0.03827	-8.71743,0.00193	-8.13829,0.00256	-8.38544,0.00226	-6.7756,0.00543	-9.16339,0.00156
13	-3.75681,0.03747	-8.40337,0.00228	-7.81135,0.00305	-8.07205,0.00267	-6.45187,0.00618	-8.85114,0.00185
14	-3.27988,0.05617	-8.46164,0.00225	-7.89683,0.00291	-8.15279,0.00256	-6.5255,0.00592	-8.93343,0.00178
15	-3.37124,0.19267	-8.81852,0.00219	-8.2141,0.00324	-8.4636,0.00275	-6.86197,0.00885	-9.25069,0.00169
16	-2.69049,0.10301	-8.5127,0.00143	-7.91725,0.00196	-8.17252,0.0017	-6.53396,0.00448	-8.95882,0.00114
17	-1.99732,0.1288	-8.08944,0.0018	-7.49395,0.00242	-7.76262,0.00208	-6.09845,0.00533	-8.51768,0.00149

ID	r	g	r'
2	16.1868	16.8984	16.194
6	16.7696	17.5087	16.777
10	16.5210	16.9415	16.525
11	15.7283	16.0337	15.731
30	18.1143	18.5278	18.118