F30: CCD photometry in modern astronomy

carried out by

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Abstract

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Zusammenfassung

Dies hier ist ein Blindtext zum Testen von Textausgaben. Wer diesen Text liest, ist selbst schuld. Der Text gibt lediglich den Grauwert der Schrift an. Ist das wirklich so? Ist es gleichgültig, ob ich schreibe: Dies ist ein Blindtext oder Huardest gefburn? Kjift – mitnichten! Ein Blindtext bietet mir wichtige Informationen. An ihm messe ich die Lesbarkeit einer Schrift, ihre Anmutung, wie harmonisch die Figuren zueinander stehen und prüfe, wie breit oder schmal sie läuft. Ein Blindtext sollte möglichst viele verschiedene Buchstaben enthalten und in der Originalsprache gesetzt sein. Er muss keinen Sinn ergeben, sollte aber lesbar sein. Fremdsprachige Texte wie Lorem ipsum dienen nicht dem eigentlichen Zweck, da sie eine falsche Anmutung vermitteln.

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1 Fundamental principles of astronomical measurements

1.1 Detectors in Astronomy

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1.4 Basics of photometry

What we are observing in our measurements is the **radiation flux** F of the stars which is given by

$$F = \frac{L}{4\pi d^2} \tag{1.1}$$

where d is the distance between the observer and the star and L is his luminosity.
To normalize our measured values we are using the sun as reference for the units we choose. For example the luminosity of the sun is $1\ L_\odot = 3.846 \cdot 10^{26}$ W.
The **Stefan-Boltzmann law** explains the connection between the surface temperature of a star and his flux. It is given by

$$F = \sigma\, T_{\text{eff}}^4 \tag{1.2}$$

with the Stefan-Boltzmann constant $\sigma = 5.67 \cdot 10^{-8}\ \text{Wm}^{-2}\text{K}^{-4}$. To understand the meaning of the effective temperature T_{eff} we need the know what we understand as a black body. A black body is, in theory, an object that absorbs every radiation independent on the corresponding wavelength and does'nt reflect any of it. The effective temperature in (1.2) is the temperature a black body with the same surface as the star would need to emit the same radiation power.
We already introduced a new quantity, the luminosity of a star which is defined as the surface area A times the flux. From this we can derive a relation between luminosity and temperature using (1.2):

$$L = 4\pi R^2 \sigma T_{\text{eff}}^4 \tag{1.3}$$

with the radius R of the star.

1.5 Magnitudes

We need to introduce different magnitude scales due to the fact that every instrumental setup is different but still we need to compare results taken from various observations.

1.5.1 Instrumental Magnitude

1.5.2 Apparant Magnitude

1.5.3 Absolute Magnitude

2 Globular Cluster BS90[14]

In this part of the experiment we are analyzing the properties of the globular cluster BS90[14]. Unfortunately the bad weather conditions during our measurement prevented us from collecting data by ourselves. Instead we are working with images taken by the Hubble Space Telescope (HST).
The goal of this part is to perform PSF fitting for two different filter constellations and match both images and finally plot a Color Magnitude Diagram (CMD) to determine age, distance and metallicity of the cluster after fitting isochrones.

2.1 Zeropoint calibration

To calibrate the measured data to a standard scale, which is in this case the apparent magnitude scale, we are comparing the counts of several standard stars with reference values from SIMBAD, an astronomical data base. From these results we can determine the zeropoint p_0 using equation ():

$$p_0 = m_{\text{CATALOG}} + 2.5 \log_{10}(\text{counts}) \tag{2.1}$$

We choose ten suitable stars, e.g. stars that are clearly isolated and bright enough but not saturated. The results of our measurement are enlisted in the following table.

Star	Mag_V	$\#_\text{V}$	$\Delta\#_\text{V}$	$p_{0,\text{V}}$	$\Delta p_{0,\text{V}}$	Mag_I	$\#_\text{I}$	$\Delta\#_\text{I}$	$p_{0,\text{I}}$	$\Delta p_{0,\text{I}}$
1	17.78	908	30	25.175	0.036	16.65	1881	43	24.836	0.025
2	17.77	1371	37	25.613	0.029	16.21	4274	65	25.287	0.017
3	17.67	1345	37	25.492	0.030	16.81	3994	63	25.814	0.017
4	17.50	1052	32	25.055	0.033	16.64	2281	48	25.035	0.023
5	17.24	1511	39	25.188	0.028	15.79	4605	68	24.948	0.016
6	18.45	808	28	25.719	0.038	17.10	1738	42	25.200	0.026
7	18.23	885	30	25.597	0.037	16.23	2073	46	24.521	0.024
8	18.09	790	28	25.334	0.038	16.93	1626	40	24.958	0.027
9	17.97	961	31	25.427	0.035	16.68	1837	43	24.840	0.025
10	17.74	764	28	24.948	0.040	16.85	1694	41	24.922	0.026

Table 2.1: Zeropoint calibration by comparing ten stars with SIMBAD references

We take the mean of the calculated zeropoints p_0 and compute the standard deviation of our errors and the error progation to get the final results:

$$p_{0,\mathrm{V}} = (25.334 \pm 0.004 \pm 0.011)$$
$$p_{0,\mathrm{I}} = (24.953 \pm 0.004 \pm 0.007)$$

References

[1] Pierre Léna. *Observational Astrophysics*. 3. Auflage. Berlin ; Heidelberg: Springer, 2012.

[2] Jörg-Uwe Pott. *FP 30: CCD photometry in modern astronomy - manuel*. Version 4.0.3. MPI for Astronomy, Heidelberg, 2017.

[3] Albrecht Unsöld and Bodo Baschek. *Der neue Kosmos. Einführung in die Astronomie und Astrophysik*. 7. ed. Berlin ; Heidelberg: Springer Spektrum, 2015.

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