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Declaration: By submitting this assignment I confirm that it is all my own work and that all references and quotations from primary and secondary sources have been fully identified and properly acknowledged.	
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Date: 1.12.2014 **Wolfgang Krispler**

Title: Expirement 1 – The Hertzsprung Russell Diagram

Abstract
An observational HR diagram for the 20 nearest (group1) and 20 brightest stars (group2) was plotted with Excel 2014 with given and calculated values.
The percentage of main sequence stars was 65% (18 from group 1, 7 from group 2). 2 stars of group 1 were white dwarfs, group 2 also contained 8 giants and 5 supergiants.

The result indicates that main sequence stars dominate our Galaxy.

The hypothetical question how the night sky would appear if all stars would possess the same luminosity as the sun or Barnard's star was analysed with Excel diagrams leading to the conclusion that in case of the sun the night sky would have less bright stars and in case of Barnard's star with the naked eye no stars at all would be visible anymore.

The result indicates that the luminosity of the sun and Barnard's star is below average compared to the other stars in our galaxy.

Cassiopeia has been observed with the naked eye, the 5 main stars have been ordered from brightest to faintest and the limiting magnitude has been estimated. 5 bright stars have been observed with the naked eye and Binoculars to comment on their color difference.

The ordering according to the apparent magnitude could be done with a little error which demonstrates that the naked eye is capable to distinguish between minor differences in brightness. The limiting magnitude in an area of high light pollution was +3.65.

It was very difficult to note color differences with the naked eye, with binoculars some differences could be noted.

Part1- HR-diagram

Introduction
An observational Hertzsprung Russell diagram was plotted including the sun, the 20 nearest and the 20 brightest stars. The diagram was analysed in terms of differences between those groups of stars. Luminosity classes were discussed plotting a B-V diagram as a function of the spectral class.

Apparatus/Method/Procedure
- Excel 2014 was used to create the data tables and plot the diagrams.
- The distance modulus equation was used to calculate the missing value for the absolute magnitude of the nearest stars from the apparent magnitude and the distance

Measurements and Graphs of Raw Measurements

Table 1.1 shows the data used to plot the HR diagram. Stars 1-20 are the top 20 nearest stars, stars 21-40 are the top 20 brightest stars.

Table 1.1

#	Star Name	App Mag	Distance (pc)	B-V Color Index	Absolute Magnitude
1	Proxima Centauri	11.01	1.30	1.97	15.44
2	α Cen A	-0.01	1.35	0.68	4.34
3	α Cen B	1.35	1.35	0.88	5.70
4	Barnard's Star	9.54	1.82	1.74	13.24
5	Wolf 359	13.45	2.39	2.01	16.56
6	HD95735	7.49	2.55	1.51	10.46
7	UV Ceti A	12.41	2.62	1.8	15.32
8	UV Ceti B	13.20	2.62	1.9	16.11
9	Sirius A	-1.44	2.64	0	1.45
10	Sirius B	8.44	2.64	0.4	11.33
11	Ross 154	10.37	2.98	1.6	13.00
12	Ross 248	12.29	3.16	1.92	14.79
13	ε Eridani	3.72	3.22	0.88	6.18
14	Lacaille 9352	7.35	3.33	1.47	9.74
15	Ross 128	11.12	3.33	1.76	13.51
16	LT789-6	12.33	3.40	1.96	14.67
17	61 Cygni A	5.20	3.48	1.17	7.49
18	61 Cygni B	6.05	3.51	1.37	8.32
19	Procyon A	0.40	3.50	0.42	2.68
20	Procyon B	10.70	3.50	0.50	12.98
21	Sirius A	-1.44	2.64	0.00	1.45
22	Canopus	-0.62	95.00	0.16	-5.53
23	Arcturus	-0.04	11.24	1.23	-0.31
24	α Cen A	-0.01	1.35	0.70	4.34
25	Vega	0.03	7.68	0.00	0.58
26	Capella	0.10	12.90	0.79	-0.48
27	Rigel	0.12	235.00	-0.03	-6.69
28	Procyon	0.34	286.00	0.41	2.68
29	Achernar	0.50	22.68	-0.18	-2.77
30	Betelgeuse	0.45	200.00	1.86	-5.14
31	Hadar	0.60	107.00	-0.23	-5.42
32	Altair	0.76	5.13	0.22	2.2
33	Aldebaran	0.87	20.43	1.53	-0.63
34	Spica	0.98	80.00	-0.23	-3.55
35	Antares	1.06	185.00	1.81	-5.28
36	Pollux	1.16	10.36	1.00	1.09
37	Formalhaut	1.17	129.81	0.09	1.74
38	Deneb	1.25	1000.00	0.09	-8.73
39	Mimosa	1.25	85.00	-0.24	-3.92
40	Regulus	1.36	24.31	-0.10	-0.52

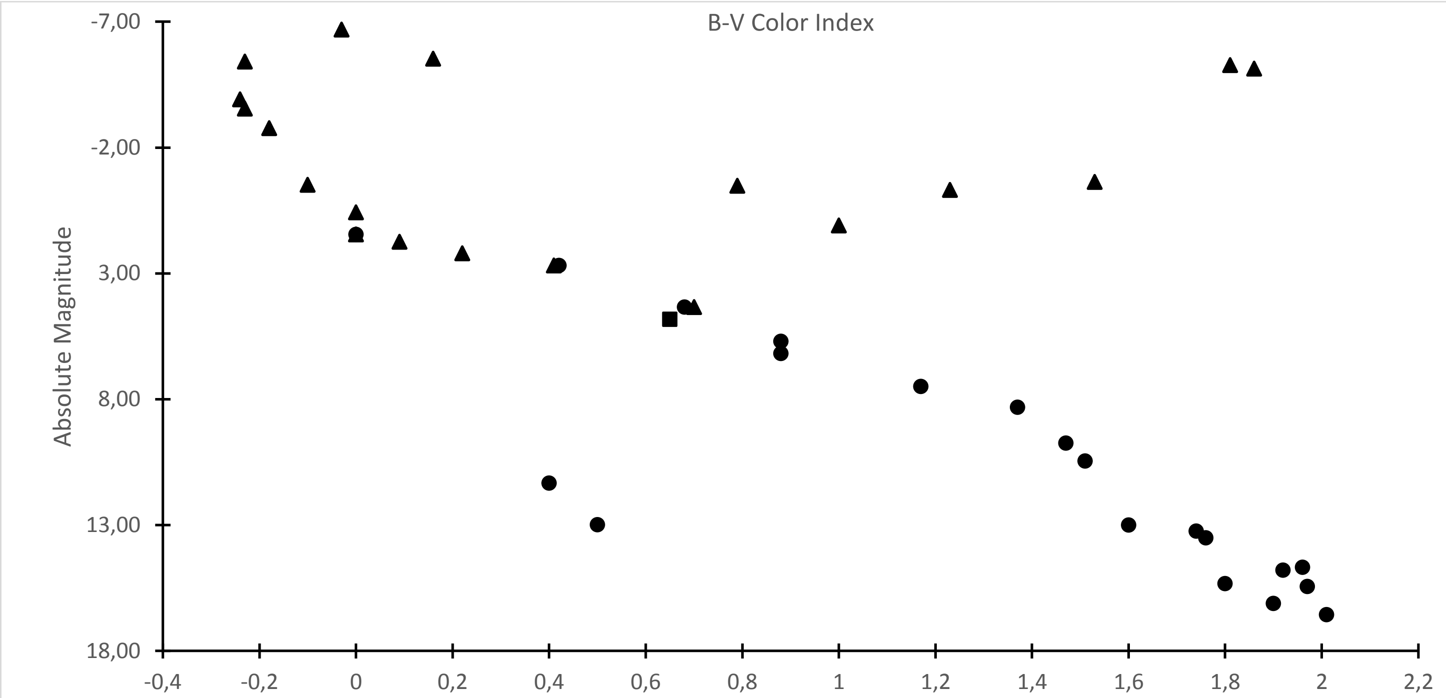


Figure 1.1- ● 20 nearest stars ▲ 20 brightest stars ■ sun

Calculations and Error Estimates

Based on the given values for the apparent magnitude and the distance of the nearest stars (Table 1.1) the absolute visible magnitude was calculated using the modulus distance formula

$m - M = 5 * logd - 5$

m..apparent magnitude
M..absolute magnitude
d..distance in parsec

To calculate e.g. the absolute visible magnitude of Proxima Centauri with an apparent magnitude of 11.01 and a distance of 1.3pc we need to enter these values in the distance modulus equation:
:
$11.01 - M = 5 * log1.3 - 5$
-M=-15.44
M=15.44

In order to calculate the appearance of a star possessing the same luminosity as the sun and Barnard's star the distance modulus equation has been used replacing M with the absolute magnitude of the sun and accordingly for Barnard's star.

The absolute magnitude of the sun is 4.83, therefore e.g. applying the distance modulus equation to Proxima Centauri with an apparent magnitude of 11.01 and a distance of 1.3 pc results in a magnitude of 0.4 if Proxima Centauri would possess the same luminosity as the sun.

$m - n = 5 * logd - 5$

m…apparent magnitude of Proxima Centauri if it would possess the same luminosity as the sun
n..absolute magnitude of the sun

$m \ = 5 * \log(1.3) - 5 + 4.83$

$m \ = 0.4$

The apparent magnitude of Barnard's star is 13.3, the calculation works similar.

Result and Discussion of HR

1. Difference between the 2 groups of the stars

90% of the nearest stars can be found on the main sequence. The 2 exceptions are Sirius B and Procyon B which are situated in the area of the white dwarfs.
35% of the brightest stars can be found on the main sequence. 8 are giants (e.g. Arcturus) and 5 are supergiants (e.g. Canopus, Betelgeuse).
3 stars (Sirius A, Alpha Centauri A and Procyon) appear on both lists. They are very close to the earth and for that reason their below average luminosity is sufficient to make them appear on the list of the 20 brightest stars.

The sample group of the nearest stars is more representative than the group of the brightest stars when wanting to make a statement about the main type of stars in our galaxy as they do not have specific properties other than being close to the earth making them a "random" sample of stars rather than one with very specific properties. The specific property of the group of brightest stars is their high luminosity.

As 90% of the stars of the first group are main sequence stars this leads to the conclusion that the type this type of stars dominate our galaxy. This complies with the accepted fact that 90% of the stars are main sequence stars whereas the 10 remaining percent are formed by white dwarfs, giants and supergiants.

2. Sun on HR diagram

The sun (square in figure 1.1) with a spectral class of G2V is a main sequence dwarf in the middle of the main sequence. It is situated very close to α Cen A (G2V, 1.1 sun masses) in the middle of the main sequence as it is intermediate in luminosity, surface temperature and radius.

3. Sky appearance if all stars would possess the same luminosity as the sun/Barnards star

If all stars would have the same luminosity as the sun the 20 nearest stars would gain significantly in brightness, the average of their apparent magnitude would go up from 7.75 to 1.91. The 20 brightest stars would lose significantly in brightness, the average of their apparent magnitude would go down from 0.49 to 7.76.Please also refer to Table 1.2 and Figure 1.2.

The apparent magnitude of the brightest star currently is -1.4 (Sirius) , if all stars would have the same luminosity as the sun the brightest star would be Proxima Centauri with an apparent magnitude of 0.4.
Limiting our analysis to just this sample of 40 stars, no stars with negative apparent magnitude would exist anymore, the number of stars with magnitude 0 would drop from 14 to 3 and the number of stars with magnitude 1 would increase from 7 to 8.

Table 1.2

Star Name	App Mag	App Mag with same luminosity as the sun.	App Mag with same luminosity as Barnards star
Proxima Centauri	11,01	0,40	8,87
α Cen A	-0,01	0,48	8,95
α Cen B	1,35	0,48	8,95
Barnard's Star	9,54	1,13	9,60
Wolf 359	13,45	1,72	10,19
HD95735	7,49	1,86	10,33
UV Ceti A	12,41	1,92	10,39
UV Ceti B	13,20	1,92	10,39
Sirius A	-1,44	1,94	10,41
Sirius B	8,44	1,94	10,41
Ross 154	10,37	2,20	10,67
Ross 248	12,29	2,33	10,80
ε Eridani	3,72	2,37	10,84
Lacaille 9352	7,35	2,44	10,91
Ross 128	11,12	2,44	10,91
LT789-6	12,33	2,49	10,96
61 Cygni A	5,20	2,54	11,01
61 Cygni B	6,05	2,56	11,03
Procyon A	0,40	2,55	11,02
Procyon B	10,70	2,55	11,02
Sirius A	-1,44	1,94	10,41
Canopus	-0,62	9,72	18,19
Arcturus	-0,04	5,08	13,55
α Cen A	-0,01	0,48	8,95
Vega	0,03	4,26	12,73
Capella	0,10	5,38	13,85
Rigel	0,12	11,69	20,16
Procyon	0,34	12,11	20,58
Achernar	0,50	6,61	15,08
Betelgeuse	0,45	11,34	19,81
Hadar	0,60	9,98	18,45
Altair	0,76	3,38	11,85
Aldebaran	0,87	6,38	14,85
Spica	0,98	9,35	17,82
Antares	1,06	11,17	19,64
Pollux	1,16	4,91	13,38
Formalhaut	1,17	10,40	18,87
Deneb	1,25	14,83	23,30
Mimosa	1,25	9,48	17,95
Regulus	1,36	6,76	15,23

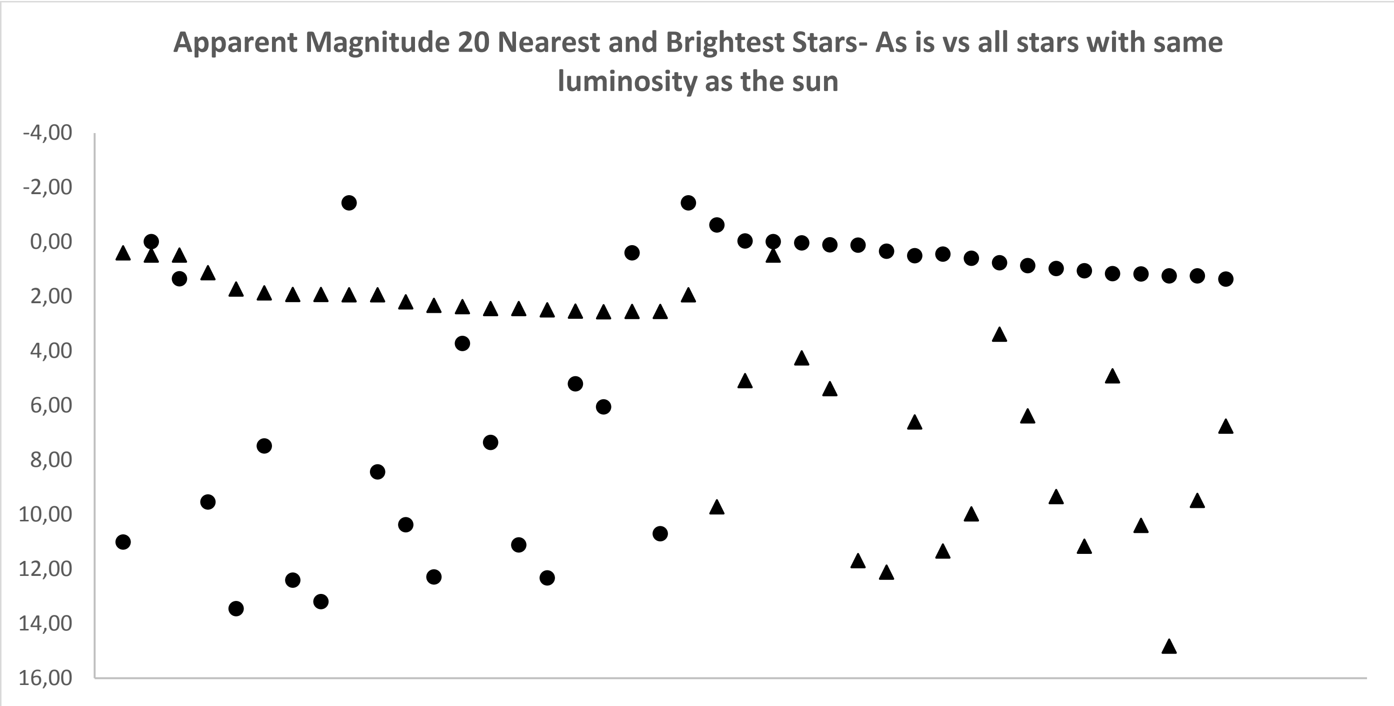


Figure 1.2- ● Apparent magnitude ▲ Apparent magnitude if all stars would have the same luminosity as the sun

If all stars would have the same luminosity as Barnard's star (absolute magnitude 13.3) the situation would be very different. The brightest star would have an apparent magnitude of 8.87 meaning that we could not see a single star with the unaided eye.

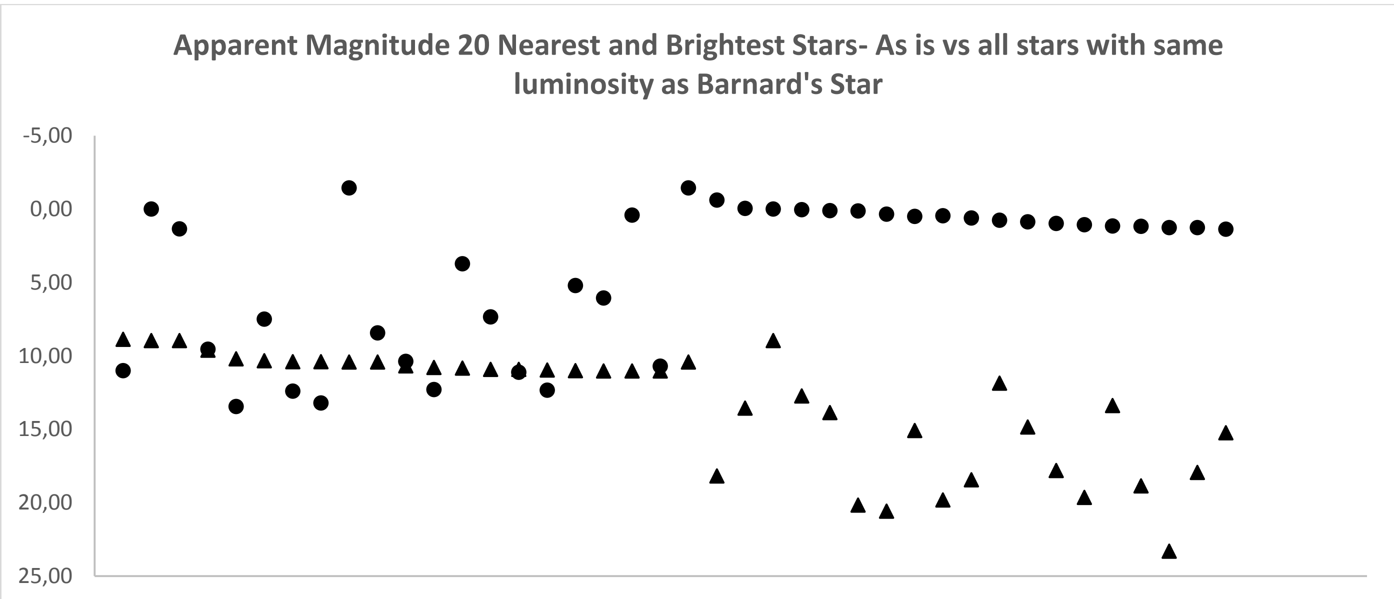


Figure 1.3 - ● Apparent magnitude ▲ Apparent magnitude if stars would have the same luminosity as Barnard's star

4. Relationship between spectral class, color index and effective temperature

Theorists are using the effective temperature on the x-axis of the HR Russell diagram.
Observers are using the spectral class determined by spectral observations and the color index determined by photometric observations.

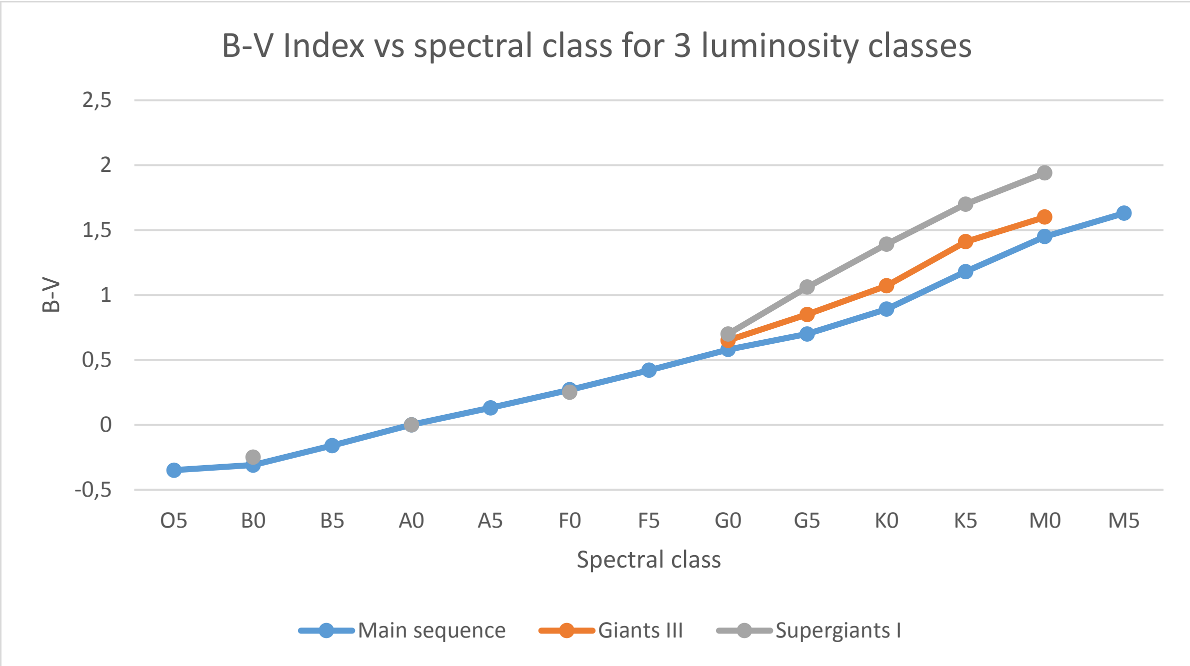


Figure 1.4

For spectral classes at the right side of the diagram starting at G0 (cooler stars) the B-V values from the 3 luminosity classes differ such that the B-V values of the Supergiants exceed the ones of the Giants and those exceed the B-V values of the main sequence luminosity class for the same spectral class.

Luminosity classes have been introduced to account for the variety of star sizes, the luminosity of a star depends beside the temperature on the size of a star.

The difference in the lines is due to the different sizes of the stars in the corresponding spectral class. Supergiant stars are bigger than giant stars and they are bigger than main sequence stars.

Conclusion of HR

90% of the nearest stars are main sequence stars, whereas only 35% of the brightest stars are main sequence stars. The majority of the brightest stars is formed by giants and supergiants with a very high luminosity. There are only 3 exceptions, stars which appear on the list of the nearest stars as well as on the list of brightest stars.

Even though the second group can’t be considered as a representative sample of stars populating our universe because of their high luminosity, 63% of the whole sample are main sequence stars.

This leads to the conclusion that main sequence stars dominate our universe which is an accepted fact. According to the literature more than 90% of all stars are situated on the main sequence.

If all stars possessed the same luminosity as the sun or Barnard’s star the night sky would become darker, in the case of Barnard’s star no stars at all would be visible anymore with the naked eye. This leads to the conclusion that those main sequence stars are with respect to their luminosity below the average of the majority of stars within our milky way.

Figure 1.4 illustrates that the B-V value is not only a function of the spectral class of a star but additionally depends on its luminosity class which is a directly depending on the size of a star (giant, supergiant or dwarf).

Part 2 – Observations

Introduction

The constellation Cassiopeia was observed with the naked eye, its 5 main stars have been ordered from brightest to faintest. The limiting magnitude was estimated with a star close by near to the limit of faintness. 5 bright stars (Capella, Vega, Deneb, Altair, and Aldebaran) were observed with the unaided eye and binoculars to comment on the color difference.

Apparatus

1. The unaided eye was used to order the 5 main stars of Cassiopeia from brightest to faintest and to estimate the limiting magnitude
2. As with the unaided eye no significant color difference could be observed binoculars (Olympus 8*21) were used in a second step.
3. Stellarium Software has been used to identify the observed star near the limit of faintness
4. The Oculum star map was used for the identification of the stars.

Method/Procedure

After identifying Cassiopeia with the unaided eye the constellation has been sketched and its 5 main stars Schedir,Caph, Tsih, Ruchbah, Segin have been assigned letters from A-E. Averted vision technique was then used to order the stars from brightest to faintest in a table.

A star close to Schedir was chosen at the limit of faintness to estimate the limiting magnitude. It was later identified via Stellarium as ξ-Cas (HIP 2920) with an apparent magnitude of 3.65.

Finally 5 stars (Capella, Vega, Deneb, Altair and Aldebaran) have been observed with the unaided eye to make a statement concerning their color.
As it was not possible to recognize differences in the color with the unaided eye binoculars were used in a second step. The observed “subjective” colors were registered in table 1.3 and compared with the the “real” colors related to the spectral class of a star (Universe table 17.2).

Observing log

Observation Log - Cassiopeia / Star Color

Observer:	Krissler Wolfgang	Date/Time:	26.10.2014 21:00 UTC
Observing Location:	47°16'36"N, 12°56'12"E	Observing Location:	Gosier Wiesen

Conditions: Cloudy, Haze, Strong Light Pollution

Temperature: 8°C Seeing: 3 (1..5) Transparency: 3 (1..7) Limiting Magnitude: +3,65

Instrument: Naked eye, Binocular (Olympus) (Naked Eye, Binocular, Telescope – Type)

Aperture: 20 mm Focal Length: ______ mm Magnification: 8 x

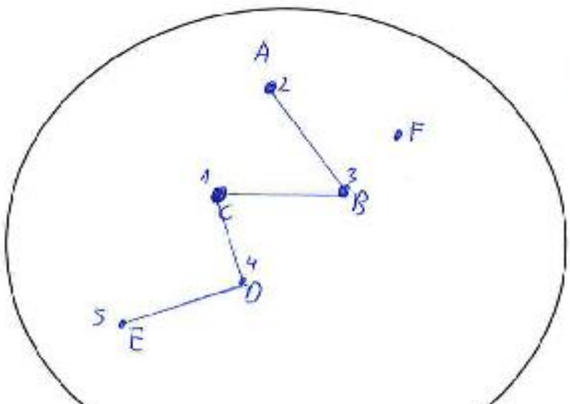
Comments:

5 main stars of Cassiopeia ordered from brightest to faintest
limiting magnitude estimated with star F close to Cassiopeia
Easy to distinguish.
A/B very similar. D/E as well

Capella, Vega, Deneb, Altair, Aldebaran observed with naked eye / binoculars

Capella	yellow
Vega	white
Deneb	yellow
Altair	orange
Aldebaran	red

Sketch:



F.. limiting magnitude

Result and Discussion

Limiting magnitude

Table 1.3

Stars sorted by Brightness based on naked eye observation	Bayer designation	HIP number	Apparent Magnitude (Vol 5 Hip Catalogue)
C-Tsih (Navi)	γ-Cas	4427	2.15
A-Caph	β-Cas	746	2.28
B-Schedir	α-Cas	3179	2.24
D-Ruchbah	δ-Cas	6686	2.66
E-Segin	ε-Cas	8886	3.35

Although the differences in the apparent magnitudes of the 5 main stars in Cassiopeia are very small it was easily possible with the unaided eye to order the stars from brightest to faintest. Except for Caph and Schedir the ordering was done correctly.

The wrong ordering of Caph and Schedir is not significant as the difference of the apparent magnitude is only 0.04 and might be due to the observing conditions.

An interesting fact though is that Tsih and Caph were qualified to be very similar in their apparent magnitude and the same statement was made for Ruchbah and Segin who differ significantly by 0.69 magnitudes. This might also be due to the observing conditions and the light pollution.

The limiting magnitude of 3.65 (estimated with ξ-Cas) was, taking the high light pollution in the observing area (please also refer to the light pollution map Figure 1.5 in the appendix) into consideration, quite high.

Color Determination

With the unaided eye it was not possible to determine differences in the colors of the observed stars. With the help of binoculars some differences could be observed. The most obvious color was observed on Aldebaran an orange giant star although the observed color red does no comply with the color for K spectral class stars (orange).

Interesting here is that in the german language an orange giant is called red giant.

Table 1.4

Star	Constellation	HIP number	Observed color (with binoculars)	Spectral class	Color (Table 17-2 Universe)
Capella	Auriga	24608	yellow	G5 III + G0 III	Yellow
Vega	Lyra	91262	white	A0 V	White
Deneb	Cygnus	102098	yellow	A2 lap	White
Altair	Aquila	97649	orange	A7 V	White
Aldebaran	Tarus	21421	Red	K5 III	Orange

Conclusion

The overall observing conditions were not optimal as a lot of fog and haze was present. The limiting magnitude was ok taking the high light pollution into consideration. The naked eye is easily capable of recognizing minimal differences in apparent magnitudes (Tsih and Caph only have a difference of 0.13 in their magnitude).

It is very difficult to make a statement about the color of a star with the naked eye although it seems easier to detect red in a star. With binoculars it was easier to comment on the differences.

Improvements could have been made in repeating the observation with better observing conditions.

Overall Conclusion

The fact that 63% of the 40 observed stars were main sequence stars leads to the conclusion that the majority of the stars in our galaxy are situated on the main sequence. The accepted value for the percentage of main sequence stars in our galaxy is 90%. The “low” observed value is a direct result of the brightest stars group which is not a representative sample due to the high luminosity value. The group of nearest stars on the contrary can be considered as a random sample without specific properties (other than being close to the earth) and fulfils perfectly the 90% expectation.

To get a statistically more significant conclusion the sample size should be increased.

The fact that the night sky would be significantly “darker” if all stars would possess the same luminosity as the sun or Barnard’s star leads to the conclusion that those 2 stars possess a below average luminosity. This is particular true for Barnard’s star with an absolute magnitude of 13.3 where no stars at all would be visible anymore with the naked eye.

By plotting the B-V color index as a function of the Spectral class for different luminosity classes it could be shown the the B-V value for the same spectral class differs depending on the luminosity class resulting in higher values for giants and supergiants.

The naked eye experiment demonstrated that the eye can easily identify minor magnitude differences but has problems in distinguishing the color of the stars.

Improvements concerning the observation could have been made by repeating the experiment under better observing conditions and by involving other observers to reduce the individual perception of colors.

Bibliography

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The 300 brightest stars.: http://www.atlasoftheuniverse.com/stars.html
All stars within 20 LY: http://www.atlasoftheuniverse.com/nearstar.html

Appendix

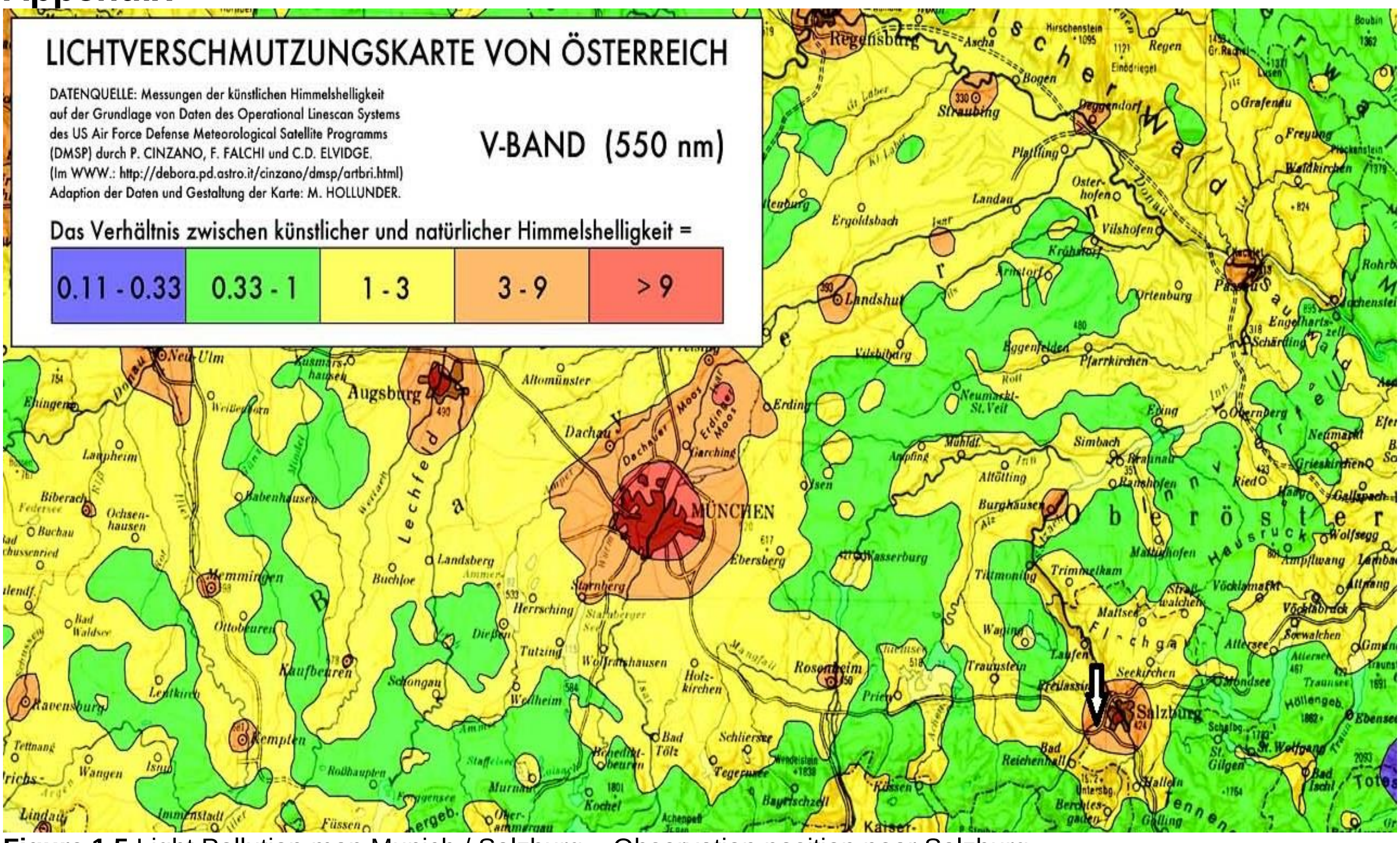

Figure 1.5 Light Pollution map Munich / Salzburg – Observation position near Salzburg