



# DARA Basic Training

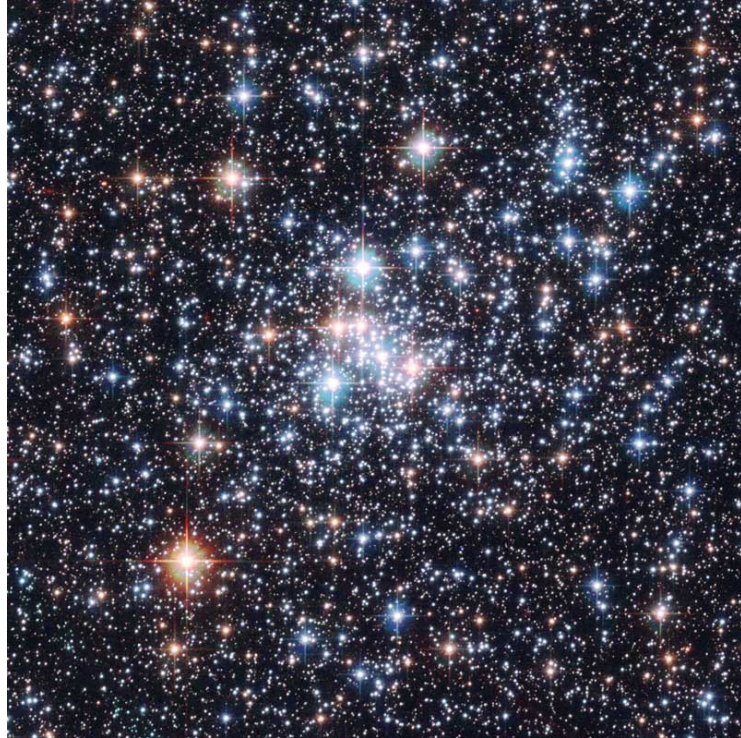
## NAMIBIA-BOTSWANA 2019

### UNIT 1: INTRODUCTION TO ASTROPHYSICS

Windhoek, 7 –18 January 2019

# Magnitudes and Colours

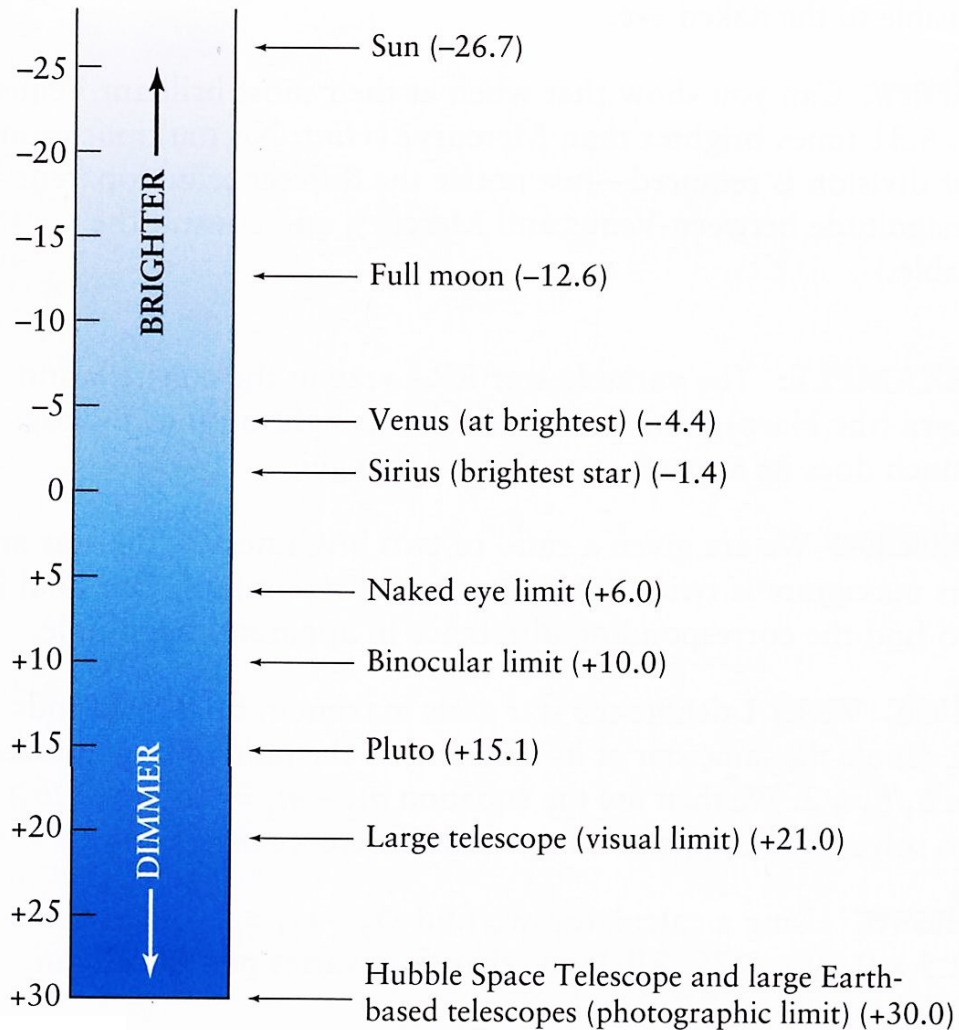
- Brightness
- Apparent magnitude
- Absolute magnitude
- Colour



# Brightness

- apparent brightness of stars is measured in magnitudes.
- historically this was a 1 to 6 scale for stars visible to the naked eye.
  - magnitude 1 = brightest
  - magnitude 6 = faintest

- now magnitude is quantified as a logarithmic scale, such that a difference of 5 magnitudes corresponds to a factor of 100 in brightness or monochromatic flux,  $f_\lambda$  in  $\text{Wm}^{-2} \mu\text{m}^{-1}$



# Pogson's Relation

- the apparent magnitudes of two stars  $m_1$  and  $m_2$  are related to their fluxes  $f_1$  and  $f_2$  by

$$\begin{aligned}\frac{f_1}{f_2} &= 100^{(m_2 - m_1)/5} \\ &= 10^{2(m_2 - m_1)/5} = 10^{0.4(m_2 - m_1)}\end{aligned}$$

$$\therefore \log \frac{f_1}{f_2} = \frac{2}{5}(m_2 - m_1)$$

$$m_2 - m_1 = 2.5 \log \frac{f_1}{f_2}$$

known as Pogson's Relation

How bright is a star with a magnitude of +4.0 compared to a star with magnitude +5.0?

- A.  $1/2.5 = 0.4$  times as bright
- B. equally bright
- C. 1.25 times brighter
- D. 2.5 times brighter
- E. 10 times brighter



$$m_2 - m_1 = 2.5 \log \frac{f_1}{f_2}$$

$$5 - 4 = 2.5 \log \frac{f_1}{f_2}$$

$$\log \frac{f_1}{f_2} = \frac{1}{2.5} = 0.4$$

$$\frac{f_1}{f_2} = 10^{0.4} = 2.51$$

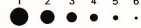
# Apparent Magnitude

- The apparent magnitude,  $m$ , of a star is defined relative to the star Vega, which is defined to have a magnitude of zero.
- The flux of Vega is referred to as the 'zero magnitude flux' and is the zero point for the magnitude scale.

# MAP 13

EPOCH 2000.0

STELLAR MAGNITUDES



DOUBLE OR MULTIPLE STARS

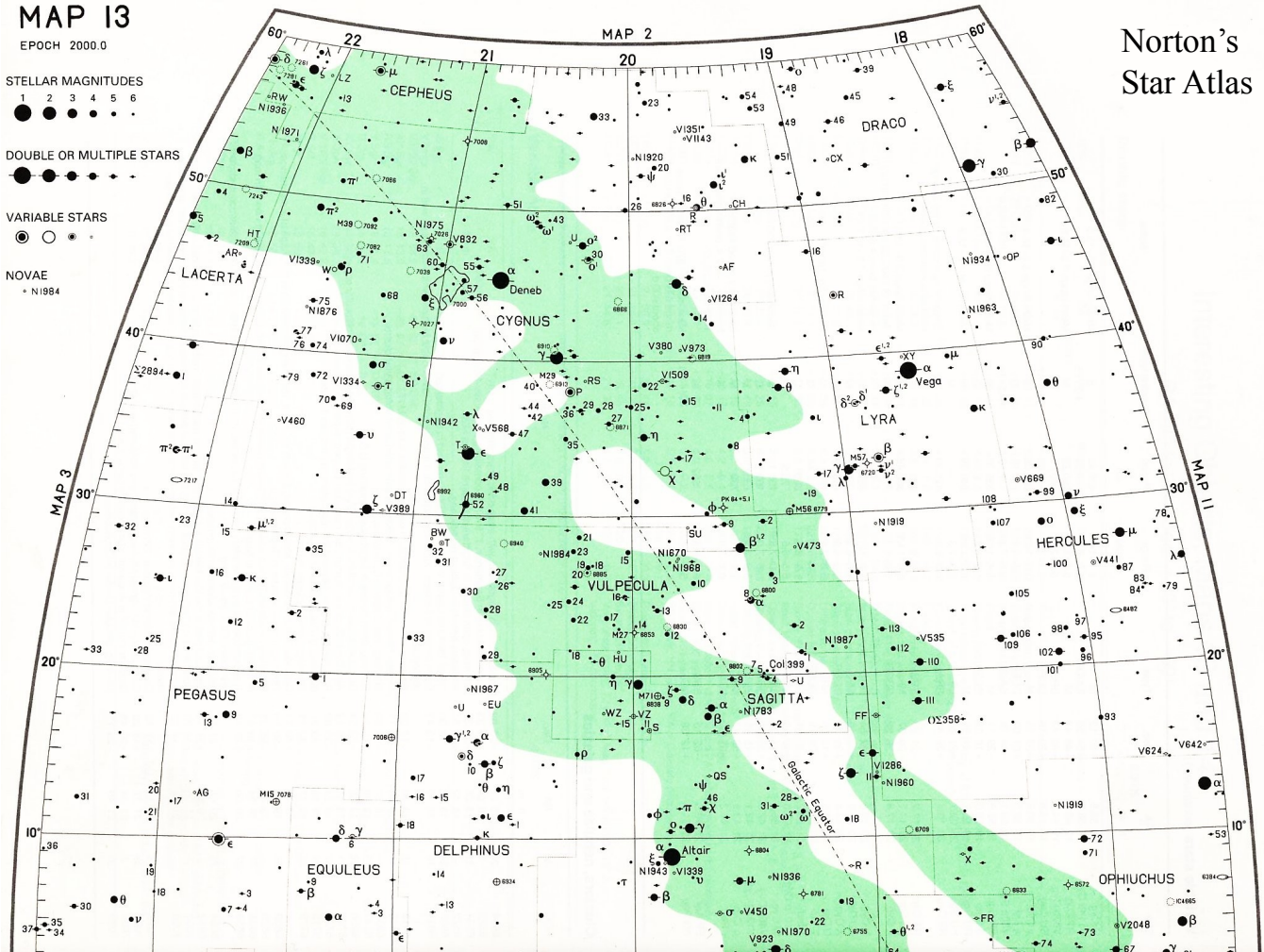


VARIABLE STARS



NOVAE

• N1984



Norton's  
Star Atlas

# Absolute brightness

- Apparent brightness depends on both the luminosity or power  $L$  (W or  $\text{Js}^{-1}$ ) of the star and its distance  $d$  (m or pc)
- An intrinsically luminous star which is far away can have a similar apparent brightness to an intrinsically faint one nearby.
- To compare absolute brightness need to define a reference distance  $D$ .

# Absolute Magnitude

- Absolute magnitude,  $M$ , is the apparent magnitude a star would have if it was at a distance  $D=10$  parsecs.

$$\text{Since } \frac{f(D)}{f(d)} = \left(\frac{d}{D}\right)^2$$

$$m - M = 2.5 \log \frac{f(D)}{f(d)} = 2.5 \log \left(\frac{d}{D}\right)^2$$

Taking  $D = 10$  pc and if  $d$  is in pc

$$m - M = 5 \log \frac{d}{10}$$

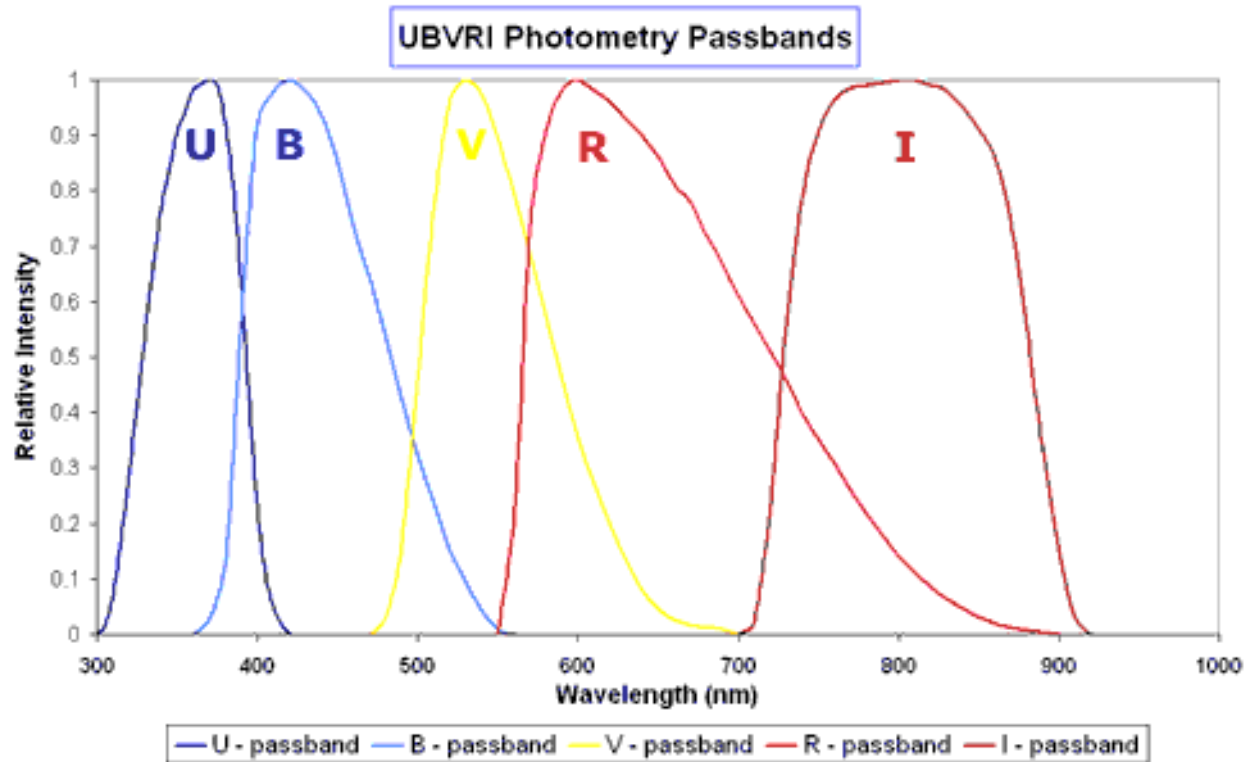
$$m - M = 5 \log d - 5$$

# Stellar Colours

- Stars will have different brightnesses in different wavelength regions.
- Hot stars are relatively blue
- Cool stars are relatively red.
- Measure this by obtaining brightness through different filters such as the Blue (B band) at 430 nm and Visible (V band) at 550 nm



Credit: ESA & NASA; Acknowledgement: E. Olszewski (U. Arizona) HST

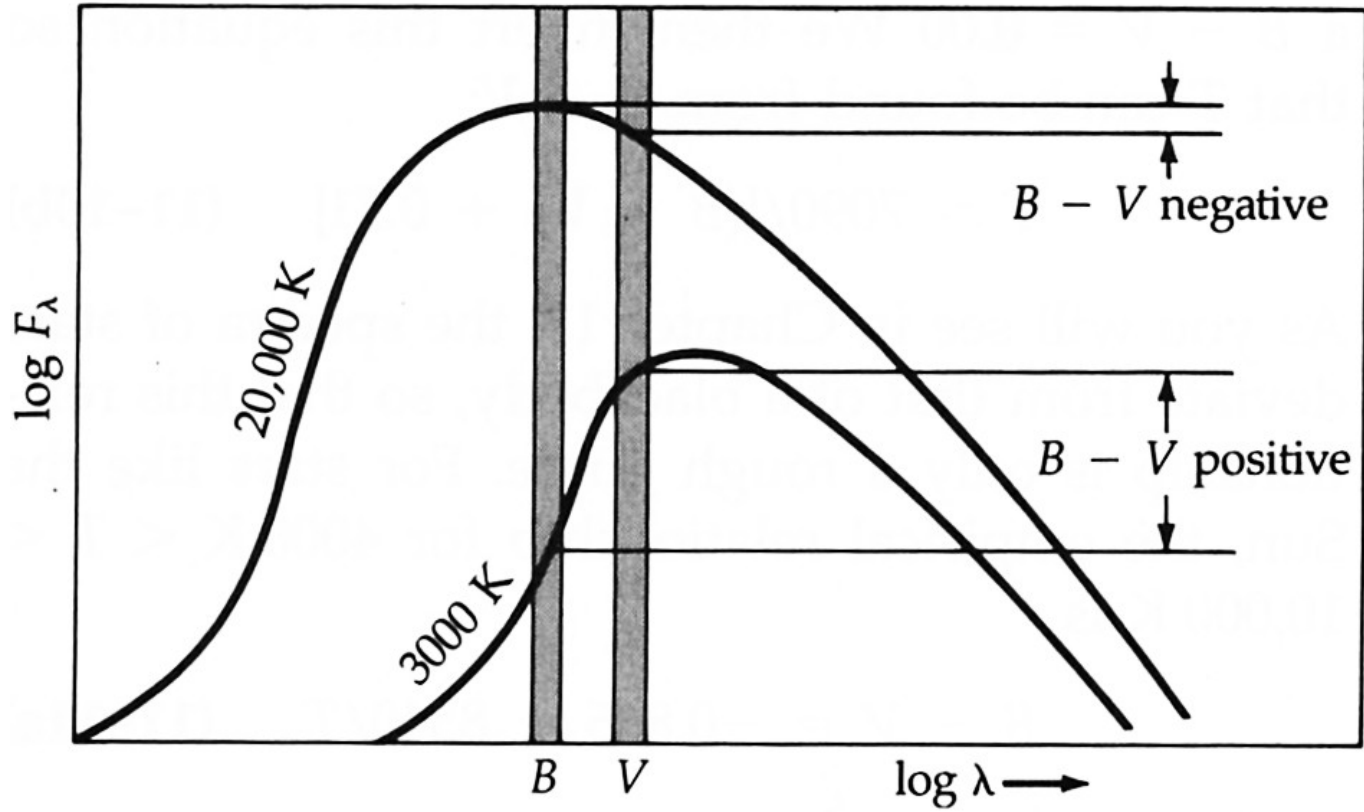


Credit: Data from M. Bessell

- can measure apparent magnitude through these filters to give:

$m_B$  and  $m_V$  also written as B and V

- if  $m_B < m_V$  or B-V is negative then the star is blue
- if  $m_B > m_V$  or B-V is positive then the star is red
- magnitude calibrated relative to the star Vega which is defined to be zero magnitude in all wavebands
- Vega ( $T_{\text{eff}}=10\,000\text{ K}$ )  $m_B=m_V=0.0$  and B-V=0.0  
whilst the Sun ( $T_{\text{eff}}=5\,800\text{ K}$ ) has B-V=+0.6  
and e.g.  $\epsilon$  Ori ( $T_{\text{eff}}=25\,000\text{ K}$ ) has B-V=-0.2



Zeilik Fig 11-4

# Summary

- the logarithmic magnitude scale is used to measure the brightness of star, both apparent and absolute
- the brightness of stars in different colour filters is used to quantify the colour of stars
- the colour of a star is related primarily to its surface temperature