THE STARS

Astronomical Magnitudes:

Astronomical magnitudes are dimensionless values. They are the ratio of a star's radiation, to that of some standard star .

The standard star used is Vega. Thus, Vega has U = V = B = 0 values by definition so Vega has zero color indices.

القدر الفلكي هي قيم بدون أبعاد. وهي نسبة إشعاعية النجم، إلى نسبة بعض النجوم القياسية.

النجم القياسي المستخدم هو فيكا. وبالتالي، فيكا لديه u = v = b = 0 قيم بحكم التعريف، لذا فإن فيكا له مؤشرات ألوان صفرية.

A. **The apparent magnitude (m):** Astronomers divided the visible stars into six classes according to their apparent brightness. The first class contained the brightest stars and the sixth the faintest ones still visible to the naked eye.

The apparent magnitude of a celestial object is a number that is a measure of its brightness as seen by an observer on Earth. The Sun, at apparent magnitude of −27, is the brightest object in the sky. The response of the human eye to the brightness of light is not linear, but logarithmic, therefor the magnitude scale is logarithmic.

قسم علماء الفلك النجوم المرئية إلى ست فئات وفقًا لسطوعها الظاهري. احتوت الفئة الأولى على ألمع النجوم والسادسة على أخفت النجوم التي لا تزال مرئية للعين المجردة.

القدر الظاهري لجسم سماوي هو رقم يمثل مقياسًا لسطوعه كما يراه الراصد على الأرض. الشمس، القدرها الظاهري −27، هي ألمع جسم في السماء. إن استجابة العين البشرية لسطوع الضوء ليست خطية، بل لوغاريتمية، وبالتالي فإن مقياس القدر لوغاريتمي.

We define apparent magnitude as a logarithmic brightness ratio of a body to some standard:

$$m= -2.5\log_{10} (b/b_o) \quad \text{........(1)}$$

Where m is the apparent magnitude, b is the brightness of a body as determined through a V filter, and b_0 is the standard's brightness, the brightness of Vega. Vega has been assigned an $m = 0$. Magnitudes are dimensionless quantities, but to remind us that a certain value is a magnitude, we can write it, for example, as 5mag or 5^m.

We can show that the magnitudes m_1 and m_2 of two stars and the corresponding brightness b_1 and b_2 are related by

$$m_1-m_2=-2.5 \log_{10} (b_1/b_2) \quad \text{......2}$$

$$\log_{10}(b_1/b_2) = -0.4 (m_1-m_2)$$

$$\frac{b_1}{b_2} = 10^{-0.4(m1-m2)}$$

$$\frac{b_1}{b_2} = (2.5)^{m2-m1} \quad \text{......3}$$

Equation 1 can be rewritten as:

$b = b_o \times 10^{-m/2.5}$ ……….4

Example 1: The Sun is about 480,000 times more brightness than the full Moon. What is the difference in their apparent magnitude?

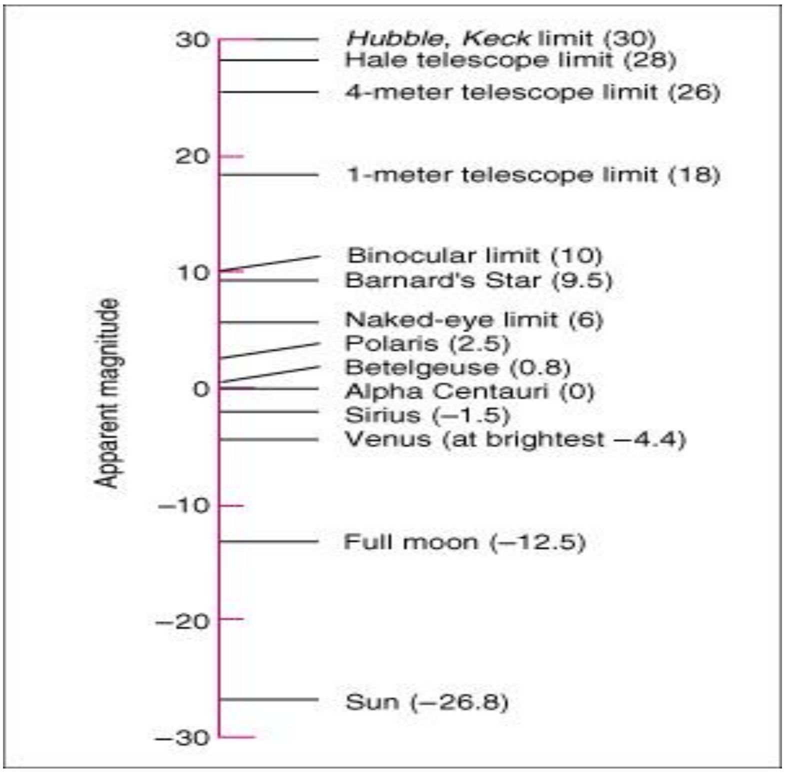
$b_{moon} = 1$, $b_{sun} = 480000$

$\Delta m = -2.5\log (b_{sun}/b_{moon}) = -2.5\log (480000/1) = -14.2$ magnitude.

Example 2: The individual apparent magnitudes of two binary stars are +2 and +4. What is the combined apparent magnitude of the binary system?

$(b_{binary} /b_o) = (b_{+2} /b_o) + (b_{+4} /b_o) =10^{-4/2.5} + 10^{-2/2.5} =0.1836$

$m_{binary} = -2.5\log (b_{binary} /b_o) = -2.5 \log(0.1836) = 1.840$ magnitude



B. **Absolute magnitude M** is the apparent magnitude the star would have if it were placed at a distance of 10 parsecs from the Earth.

From the *inverse square law for light*, the ratio of its brightness at 10 pc to its brightness at its known distance d (in parsecs) is

القدر المطلق M هو القدر الظاهري للنجم إذا وُضِع على مسافة 10 فرسخ فلكي من الأرض.

من قانون التربيع العكسي للضوء، فإن نسبة سطوعه عند 10 فرسخ فلكي إلى سطوعه عند مسافته المعروفة d (بالفرسخ الفلكي) هي

$b_{10} /b_d = (d/10)^2$ ……..5

Then, like the formula above, we say that its absolute magnitude is

$M = m - 5\log_{10}(d/c)$ …….6

C is a constant that depends on the units that the distance to the star is measured.

if d is in parsecs, then C = 10 (= number of pc in 10 pc)

if d is in lightyears, then C = 32.616 (= number of ly in 10 pc)

if d is in AU, then C = 2062641.61 (= number of AU in 10 pc)

if d is in kilometres, then C = 3.08571e14 (= number of km in 10 pc)

- A star at a distance of 10 parsecs has m-M = 0
- If the star is closer than 10 parsecs, then m-M < 0 because m < M
- If a star is further than 10 parsecs, then m - M > 0 because m > M

Calculate the Absolute Magnitude of the star, in solar units (b), the equation is

$$M = 4.83 - 2.5\log_{10}b \quad \text{………7}$$

Where: M = Absolute magnitude of the star (magnitude if viewed from 10 pc)

b = brightness of star expressed in solar units

Example:

1) Procyon is an F5 IV star that is 7.36 times brighter than Sun and 11.4 ly from Earth. What are its Absolute (M) and Apparent (m) magnitude?

M = 4.83 - 2.5log(7.36), so M = 2.66.

m = 2.66 + 5log(11.4/32.616), so m = 0.38.

These values agree with the real values, so this shows that the equations work!

2) What is the apparent magnitude of Sun as seen from Procyon?

The Absolute Magnitude of the sun is 4.83 (looking eq 7, log(1) = 0, so M = 4.83).

3) What is the apparent magnitude of Sun as seen from Neptune? Neptune is 30 AU from Sun.

C. **The bolometric magnitude** M_{bol}, it is the same magnitude (apparent and absolute) but takes into account electromagnetic radiation at all wavelengths. It includes those unobserved due to the Earth's atmospheric absorption, and extinction by interstellar dust. It is defined based on the luminosity of the stars.

المقدار البولومتري Mbol، وهو نفس المقدار (الظاهري والمطلق) ولكنه يأخذ في الاعتبار الإشعاع الكهرومغناطيسي بجميع أطوال الموجات. ويشمل ذلك الإشعاعات غير المرصودة بسبب امتصاص الغلاف الجوي للأرض، وانقراضها بواسطة الغبار بين النجوم. ويتم تحديده بناءً على لمعان النجوم.

The absolute bolometric magnitude can be expressed in terms of the luminosity. Let the total flux density (total brightness) at a distance r = 10 pc be F and let $F_\odot$ be the equivalent quantity for the Sun. Since the luminosity is $L = 4\pi r^2 F$, we get