$$B = B_0 10^{-0.4m}$$

Since the time of the Greek astronomer Hipparchus (190BC), astronomers have used a 'magnitude' scale to indicate the brightness of stars. A star of the First Magnitude (+1.0) is brighter than a star of the Second Magnitude (+2.0) and so on, which means that, the more positive a star's magnitude is, the fainter is the star! Although modern astronomers would have preferred a more conventional scale, we are basically stuck with this ancient convention.

On the stellar magnitude scale, a difference of 5 magnitudes is exactly a brightness difference of 100 times. This magnitude scale, **m**, is related to a physical brightness scale, **B**, using the formula shown to the left.

The star field image is from the Hubble Space Telescope Exoplanet Survey and shows a range of stellar brightnesses spanning a magnitude range from about +13 to +17

Problem 1 - In this formula, to what magnitude does a brightness of B_0 correspond?

Problem 2 - The sun has a magnitude of -26.5, and the faintest star detected by the Hubble Space Telescope has a magnitude of +28.5 A) What is the magnitude difference between these two objects? B) By what factor to they differ in brightness?

Problem 3 - An astronomer has a digital camera that can accommodate a brightness level change of about 10 million from the brightest to the faintest object that can be imaged without 'saturating' the camera. What magnitude difference does this range correspond to?

Problem 4 - NASA's WISE infrared sky survey satellite will detect stars at a wavelength of 4.6 microns (called M-band) to a brightness limit of 160 microJanskys. If B0 is 180 Janskys at this wavelength, and for the visual magnitude scale (called V-band) B0 = 3,781 Janskys. What will be the equivalent magnitude limit of the WISE survey at 4.6 microns, and in the visual band?

Problem 1 - In this formula, to what magnitude does a brightness of B_0 correspond?

Answer: It corresponds to m=0 .This means that B_0 establishes the 'zero-point' for this magnitude scale.

Problem 2 - The sun has a magnitude of -26.5, and the faintest star detected by the Hubble Space Telescope has a magnitude of +28.5 A) What is the magnitude difference between these two objects? B) By what factor do they differ in brightness?

Answer: A) 28.5 - (-26.5) = **55 magnitudes**! B) From the formula, the brightness ratio will be $10^{0.4(55)}$ = **10^{22} times** (or alternately 10^{-22} times).

Problem 3 - An astronomer has a digital camera that can accommodates a brightness level change of about 10 million from the brightest to the faintest object that can be imaged without 'saturating' the camera. What magnitude difference does this range correspond?

Answer $10^7 = 10^{0.4(m)}$ so m = **17.5 magnitudes**.

Problem 4 - NASA's WISE infrared sky survey satellite will detect stars at a wavelength of 4.6 microns (called M-band) to a brightness limit of 160 microJanskys. If B0 is 180 Janskys at this wavelength, and for the visual magnitude scale (called V-band) B0 = 3,781 Janskys. What will be the equivalent magnitude limit of the WISE survey at 4.6 microns, and in the visual band?

Answer: For M-band, 0.000160 Jy = 180 Jy $10^{-0.4m}$ so m(M-band) = **+15.1**
For V-band, 0.000160 Jy = 3,781 Jy $10^{-0.4m}$ so m(V-band) = **+18.4**. So, the same brightness level in V-band corresponds to a magnitude of +18.4 which is +3.3 magnitudes fainter than in M-band.