## ARE A STAR'S BRIGHTNESS AND LUMINOSITY THE SAME THING?

Renaissance woodcut called Empedocles Breaks through the Crystal Spheres

The ancient astronomers believed the stars were attached to a gigantic crystal sphere surrounding Earth. In that scenario, all stars were located at the same distance from Earth, and so, to the ancients, the magnitude and brightness of stars depended only on the stars themselves (see Magnitude below). In our cosmology, the stars we see are located at very different distances from us, from several light-years to over 1,000 light-years. Telescopes show the light of stars millions or billions of light-years away.

**A star's luminosity is its true brightness**. Nearly every star you see with the unaided eye is more luminous than our sun. Today, when we talk about a star's brightness, we might mean one of two things: its intrinsic brightness or its apparent brightness. When astronomers speak of the luminosity of a star, they're speaking of a star's intrinsic brightness, how bright it really is. A star's apparent magnitude – its brightness as it appears from Earth – is something quite different and depends on how far away we are from that star.

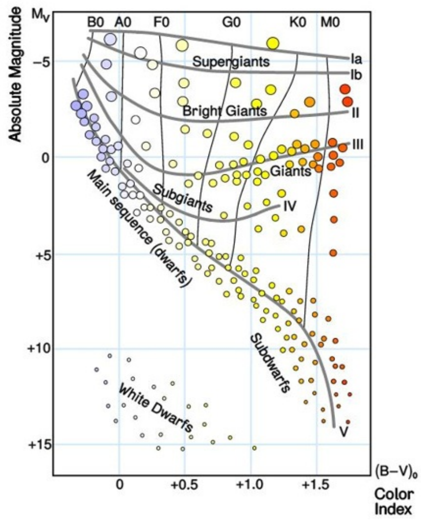
**Astronomers often list the luminosity of stars in terms of solar luminosity**. The sun has a radius of about 696,000 kilometers, and a surface temperature of about 5800 Kelvin, or 5800 degrees above absolute zero. Freezing point of water = 273 Kelvin = 0 Celsius. Nearly every star that you see with the unaided eye is larger and more luminous than our sun. The vast majority of stars that we see at night with the eye alone are millions – even hundreds of millions – of times farther away than the sun. Regardless, these distant suns can be seen from Earth because they are hundreds or thousands of times more luminous than our local star.

A star's luminosity depends on two things:

1. Radius measure
2. Surface temperature

Let's presume a star has the same surface temperature as the sun, but sports a larger radius. In that scenario, the star with the larger radius claims the greater luminosity. If we say the star's radius is 4 times the sun's radius) but has the same surface temperature as our sun, then it luminosity will be $4^2$ = 16 times the sun's luminosity. The star VY Canis Majoris radius is thought to be around 1400 times than of our sun, and its luminosity is 270,000 greater than our sun.

**If a star has the same radius R as the sun but twice the surface temperature T, the hotter star exceeds the sun in luminosity $T^4$ = 16 times. The luminosity of any star is the product of the radius squared times the surface temperature to the fourth power.**




The HR Diagram categorizes stars by surface temperature and luminosity. Hot blue stars, over 30,000 Kelvin, at left; and cool red stars, less than 3,000 Kelvin, at right. The most luminous stars – over 1,000,000 solar - are at top, and the least luminous stars - 1/10,000 solar - at bottom.

COLOUR AND SURFACE TEMPERATURE

Colour is a telltale sign of surface temperature. The hottest stars radiate blue or blue-white, whereas the coolest stars exhibit distinctly ruddy hues. Our yellow-coloured sun indicates a moderate surface temperature in between the two extremes. Spica serves as prime example of a hot blue-white star, Altair: moderately-hot white star, Capella: middle-of-the-road yellow star, Arcturus: lukewarm orange star and Betelgeuse: cool red supergiant.

MAGNITUDE

An imprecise but systematic determination of the visual magnitude of objects in the sky was introduced in ancient times by the Greek astronomer **Hipparchus of Nicaea** (190-120BC. He classified the stars on a scale from 1 to 6, for the brightest to the dimmest star visible to the naked eye respectively; the brighter an object appears, the more prominence is given to it. The system was a simple delineation of stellar brightness into six distinct groups, but made no allowance for the variations in brightness within a group.

In 1856 **Norman Pogson** of Oxford proposed that a logarithmic scale of approx 2.512 be adopted between magnitudes, so five magnitude steps $(2.512)^5$ corresponded precisely to a factor of 100 in brightness. Consequently, a first magnitude star is about 2.5 times brighter than a second magnitude star, $2.5^2$ brighter than a third magnitude star, $2.5^3$ brighter than a fourth magnitude star, and so on. In modern times this range has been extended both up and down: The Sun has a magnitude of -27, the full moon -13, the brightest planet Venus measures -5, and Sirius, the brightest visible star in the night sky, is at -1.5. On that scale the empty background of the night sky has a magnitude of +28.

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