= Betelgeuse =

Betelgeuse , also known by its Bayer designation Alpha Orionis (shortened to ? Orionis or ? Ori) , is the ninth @-@ brightest star in the night sky and second @-@ brightest in the constellation of Orion . Distinctly reddish , it is a semiregular variable star whose apparent magnitude varies between 0 @.@ 0 and 1 @.@ 3 , the widest range of any first @-@ magnitude star . Betelgeuse is one of three stars that make up the Winter Triangle , and it marks the center of the Winter Hexagon . The star 's name is derived from the Arabic ??? ??????? Ibt al @-@ Jauz? ' or ?? ??????? Yad al @-@ Jauz? ' , meaning " the hand of Orion " .

The star is classified as a red supergiant of spectral type M1 @-@ 2 and is one of the largest and most luminous observable stars . If Betelgeuse were at the center of the Solar System , its surface would extend past the asteroid belt , possibly to the orbit of Jupiter and beyond , wholly engulfing Mercury , Venus , Earth and Mars . Estimates of its mass are poorly constrained , but range from 5 to 30 times that of the Sun . Its distance from Earth was estimated in 2008 at 640 light @-@ years , yielding a mean absolute magnitude of about ? 6 . Less than 10 million years old , Betelgeuse has evolved rapidly because of its high mass . Having been ejected from its birthplace in the Orion OB1 Association ? which includes the stars in Orion 's Belt ? this crimson runaway has been observed moving through the interstellar medium at a supersonic speed of 30 km / s , creating a bow shock over 4 light @-@ years wide . Currently in a late stage of stellar evolution , the supergiant is expected to proceed through its life cycle before exploding as a type II supernova within the next million years . An observation by the Herschel Space Observatory in January 2013 revealed that the star 's winds are crashing against the surrounding interstellar medium .

In 1920 , Betelgeuse became the second star (after the Sun) to have the angular size of its photosphere measured . Since then , researchers have used telescopes with different technical parameters to measure the stellar giant , often with conflicting results . Studies since 1990 have produced an angular diameter (apparent size) ranging from 0 @.@ 043 to 0 @.@ 056 arcseconds , an incongruity largely caused by the star 's tendency to periodically change shape . Due to limb darkening , variability , and angular diameters that vary with wavelength , many of the star 's properties are not yet known with any certainty . Adding to these challenges , the surface of Betelgeuse is obscured by a complex , asymmetric envelope roughly 250 times the size of the star , caused by colossal mass loss .

= = Observational history = =

Betelgeuse and its red coloration have been noted since antiquity ; the classical astronomer Ptolemy described its color as ????????? (hypókirrhos) , a term that was later described by a translator of Ulugh Beg 's Zij @-@ i Sultani as rubedo , Latin for " ruddiness " . In the nineteenth century , before modern systems of stellar classification , Angelo Secchi included Betelgeuse as one of the prototypes for his Class III (orange to red) stars . By contrast , three centuries before Ptolemy , Chinese astronomers observed Betelgeuse as having a yellow coloration , suggesting that the star may have spent time as a yellow supergiant around the beginning of the common era , a possibility given current research into the complex circumstellar environment of these stars .

= = = Nascent discoveries = = =

The variation in Betelgeuse 's brightness was first described in 1836 by Sir John Herschel , when he published his observations in Outlines of Astronomy . From 1836 to 1840 , he noticed significant changes in magnitude when Betelgeuse outshone Rigel in October 1837 and again in November 1839 . A 10 @-@ year quiescent period followed ; then in 1849 , Herschel noted another short cycle of variability , which peaked in 1852 . Later observers recorded unusually high maxima with an interval of years , but only small variations from 1957 to 1967 . The records of the American Association of Variable Star Observers (AAVSO) show a maximum brightness of 0 @.@ 2 in 1933 and 1942 , and a minimum of 1 @.@ 2 , observed in 1927 and 1941 . This variability in brightness

may explain why Johann Bayer , with the publication of his Uranometria in 1603 , designated the star alpha as it may have rivaled the usually brighter Rigel (beta) . From Arctic latitudes , Betelgeuse 's red colour and higher location in the sky than Rigel meant the Inuit regarded it as brighter , and one local name was Ulluriajjuaq " large star " .

In 1920 , Albert Michelson and Francis Pease mounted a 6 @-@ meter interferometer on the front of the 2 @.@ 5 @-@ meter telescope at Mount Wilson Observatory . Helped by John Anderson , the trio measured the angular diameter of Betelgeuse at 0 @.@ 047 " , a figure which resulted in a diameter of 3 @.@ 84 × 108 km (2 @.@ 58 AU) based on the parallax value of 0 @.@ 018 " . However , limb darkening and measurement errors resulted in uncertainty about the accuracy of these measurements .

The 1950s and 1960s saw two developments that would impact stellar convection theory in red supergiants : the Stratoscope projects and the 1958 publication of Structure and Evolution of the Stars , principally the work of Martin Schwarzschild and his colleague at Princeton University , Richard Härm . This book disseminated ideas on how to apply computer technologies to create stellar models , while the Stratoscope projects , by taking balloon @-@ borne telescopes above the Earth 's turbulence , produced some of the finest images of solar granules and sunspots ever seen , thus confirming the existence of convection in the solar atmosphere .

= = = Imaging breakthroughs = = =

Astronomers in the 1970s saw some major advances in astronomical imaging technology beginning with Antoine Labeyrie 's invention of speckle interferometry , a process that significantly reduced the blurring effect caused by astronomical seeing . It increased the optical resolution of ground @-@ based telescopes , allowing for more precise measurements of Betelgeuse 's photosphere . With improvements in infrared telescopy atop Mount Wilson , Mount Locke and Mauna Kea in Hawaii , astrophysicists began peering into the complex circumstellar shells surrounding the supergiant , causing them to suspect the presence of huge gas bubbles resulting from convection . But it was not until the late 1980s and early 1990s , when Betelgeuse became a regular target for aperture masking interferometry , that breakthroughs occurred in visible @-@ light and infrared imaging . Pioneered by John E. Baldwin and colleagues of the Cavendish Astrophysics Group , the new technique employed a small mask with several holes in the telescope pupil plane , converting the aperture into an ad @-@ hoc interferometric array . The technique contributed some of the most accurate measurements of Betelgeuse while revealing bright spots on the star 's photosphere . These were the first optical and infrared images of a stellar disk other than the Sun , taken first from ground @-@ based interferometers and later from higher @-@ resolution observations of the COAST telescope . The " bright patches " or " hotspots " observed with these instruments appeared to corroborate a theory put forth by Schwarzschild decades earlier of massive convection cells dominating the stellar surface .

In 1995 , the Hubble Space Telescope 's Faint Object Camera captured an ultraviolet image with a resolution superior to that obtained by ground @-@ based interferometers ? the first conventional @-@ telescope image (or " direct @-@ image " in NASA terminology) of the disk of another star . Because ultraviolet light is absorbed by the Earth 's atmosphere , observations at these wavelengths are best performed by space telescopes . Like earlier pictures , this image contained a bright patch indicating a region in the southwestern quadrant 2000 K hotter than the stellar surface . Subsequent ultraviolet spectra taken with the Goddard High Resolution Spectrograph suggested that the hot spot was one of Betelgeuse 's poles of rotation . This would give the rotational axis an inclination of about 20 ° to the direction of Earth , and a position angle from celestial North of about 55 ° .

= = = Recent studies = = =

In a study published in December 2000 , the star 's diameter was measured with the Infrared Spatial Interferometer (ISI) at mid @-@ infrared wavelengths producing a limb @-@ darkened estimate of 55 @.@ 2 ± 0 @.@ 5 milliarcseconds (mas) ? a figure entirely consistent with

Michelson 's findings eighty years earlier . At the time of its publication , the estimated parallax from the Hipparcos mission was 7 @.@ 63 ± 1 @.@ 64 mas , yielding an estimated radius for Betelgeuse of 3 @.@ 6 AU . However , numerous interferometric studies in the near @-@ infrared made at the Paranal Observatory in Chile argue for much tighter diameters . On 9 June 2009 , Nobel Laureate Charles Townes announced that the star had shrunk by 15 % since 1993 at an increasing rate without a significant diminution in magnitude . Subsequent observations suggest that the apparent contraction may be due to shell activity in the star 's extended atmosphere .

In addition to the discussion of the star 's diameter , questions have arisen about the complex dynamics of Betelgeuse 's extended atmosphere . The mass that makes up galaxies is recycled as stars are formed and destroyed , and red supergiants are major contributors , yet the mechanics of stellar mass loss remain a mystery . With advances in interferometric methodologies , astronomers may be close to resolving this conundrum . In July 2009 , images released by the European Southern Observatory , taken by the ground @-@ based Very Large Telescope Interferometer (VLTI) , showed a vast plume of gas being ejected from the star into the surrounding atmosphere with distances approximating 30 AU . This mass ejection was equal to the distance between the Sun and Neptune and is one of multiple events occurring in Betelgeuse 's surrounding atmosphere . Astronomers have identified at least six shells surrounding Betelgeuse . Solving the mystery of mass loss in the late stages of a star 's evolution may reveal those factors that precipitate the explosive deaths of these stellar giants .

= = Visibility = =

In the night sky , Betelgeuse is easy to spot with the naked eye owing to its distinctive orange @-@ red color . In the Northern Hemisphere , beginning in January of each year , it can be seen rising in the east just after sunset . By mid @-@ September to mid @-@ March (best in mid @-@ December) , it is visible to virtually every inhabited region of the globe , except for a few research stations in Antarctica at latitudes south of 82 ° . In May (moderate northern latitudes) or June (southern latitudes) , the red supergiant can be seen briefly on the western horizon after sunset , reappearing again a few months later on the eastern horizon before sunrise . In the intermediate period (June ? July) it is invisible to the naked eye (visible only with a telescope in daylight) , unless around midday (when the Sun is below horizon) on Antarctic regions between 70 ° and 80 ° south latitude .

The mean apparent magnitude of Betelgeuse is 0 @.@ 50 , making it on average the eighth brightest star in the celestial sphere excluding the Sun . Because Betelgeuse is a variable star whose brightness ranges between 0 @.@ 0 and 1 @.@ 3 , there are periods when it will surpass Procyon to become the seventh brightest star . Occasionally it can even outshine Rigel and become the sixth brightest star . At its faintest , Betelgeuse will fall behind Deneb and Mimosa as 20th brightest star .

Betelgeuse has a color index (B ? V) of 1 @.@ 85 ? a figure which points to its advanced " redness " . The photosphere has an extended atmosphere , which displays strong lines of emission rather than absorption , a phenomenon that occurs when a star is surrounded by a thick gaseous envelope . This extended gaseous atmosphere has been observed moving away from and towards Betelgeuse , depending on radial velocity fluctuations in the photosphere . Betelgeuse is the brightest near @-@ infrared source in the sky with a J band magnitude of ? 2 @.@ 99 . As a result , only about 13 % of the star 's radiant energy is emitted in the form of visible light . If human eyes were sensitive to radiation at all wavelengths , Betelgeuse would appear as the brightest star in the sky .

= = = Parallax = = =

Since the first successful parallax measurement by Friedrich Bessel in 1838 , astronomers have been puzzled by Betelgeuse 's apparent distance . Knowledge of the star 's distance improves the accuracy of other stellar parameters , such as luminosity that , when combined with an angular

diameter , can be used to calculate the physical radius and effective temperature ; luminosity and isotopic abundances can also be used to estimate the stellar age and mass . In 1920 , when the first interferometric studies were performed on the star 's diameter , the assumed parallax was 0 @.@ 0180 arcseconds . This equated to a distance of 56 parsecs (pc) or roughly 180 light @-@ years (ly) , producing not only an inaccurate radius for the star but every other stellar characteristic . Since then , there has been ongoing work to measure the distance of Betelgeuse , with proposed distances as high as 400 pc or about 1300 ly .