Major Stars of the Orion Constellation

By Mervyn Millward

Looking north and gazing up at the sky on a Tasmanian summer evening, one can easily pick out the famous Orion (The Hunter) constellation. From this position the four major stars that make up his extremities are Rigel, Saiph, Bellatrix and Betelgeuse, together with his three “belt” stars of Alnitak, Alnilam and Mintaka as shown in Figure 1.
As these stars are viewed on the celestial sphere, the casual observer notes that Rigel is the brightest star with a blue/white appearance, while the star Betelgeuse shines bright, but with a reddish hue. The other stars appear in varying degrees of brightness, all showing the same whitish colour. Why are they a certain colour? How far are they? What are they made of? These are just some of the questions that might be asked when viewing this constellation.

With most constellations, or asterisms, the individual stars that define a particular figure are situated at varying degrees of distance from our viewing position here on the Earth and have no common “ancestry”. However, in Table 1, we see that stars in Orion’s belt, together with fainter stars above and to the right of the belt, share a common distance of approximately 1000 light years from the Earth. These stars along with Rigel, Saiph and Betelgeuse may have originated from the same molecular dust/gas cloud. Even today, star birth can be seen happening in the nearby Great Orion nebula and surrounding dust/gas clouds of this constellation. [Starryskiesweb] One way of examining the ancestry and final fate of these stars is by examining their relationships using a Hertzprung-Russel (H-R) diagram. Astronomers use this diagram to plot star luminosity against temperature (or spectral class) to gain an understanding of the relative properties between the stars. For Orion, Figure 2 shows an H-R diagram for major stars in this constellation. From this graph, we can readily see characteristics of blue Supergiants prevalent for Rigel, Alnitak, Alnilam, Mintaka, Bellatrix and Saiph. These blue Supergiants have temperatures between 20 000 and 50 000 Kelvin, 10 to 50 solar masses and can be 25 solar radii. [WikBluesupergiants] While Betelgeuse is seen as a cooler red Supergiant, typically characterised by their cooler surface temperatures of 3500 to 4500 Kelvin and if swapped with our Sun, would see star radii that can extend beyond the orbit of the Earth. [WikRedsupergiants]
<table>
<thead>
<tr>
<th>OBJECT</th>
<th>DISTANCE (LIGHT YEARS)</th>
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<tbody>
<tr>
<td>M42</td>
<td>1600</td>
</tr>
<tr>
<td>Alnilam</td>
<td>1359.01</td>
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<tr>
<td>Mintaka</td>
<td>918.77</td>
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<td>Alnitak</td>
<td>825.73</td>
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<tr>
<td>Rigel</td>
<td>776.58</td>
</tr>
<tr>
<td>Saiph</td>
<td>724.81</td>
</tr>
<tr>
<td>Betelgeuse</td>
<td>429.16</td>
</tr>
<tr>
<td>Bellatrix</td>
<td>243.41</td>
</tr>
</tbody>
</table>

Table 1

Relative Distances from the Earth [SNPro]

Fig. 2

1-Betelgeuse; 2-Rigel; 3-Bellatrix; 4-Alnitak; 5-Alnilam; 6-Mintaka; 7-Saiph

H-R Diagram of Main Orion Stars [OrionSurveyweb]
We start our comparison of major Orion stars by describing Alpha Orionis, Betelgeuse, which forms Orion’s right shoulder. It’s actually fainter than Beta Orionis (Rigel) due to a misclassification error as Betelgeuse was found to be a variable star.

[Wiscweb] “Astronomers now know that these regular brightness variations are caused by changes in the actual size of the star's atmosphere. According to Robert Burnham, Jr. (1931-93), Betelgeuse is the only marked variable among the first magnitude stars as well as the 11th brightest star in the sky. It is a well known semi-regular, pulsating variable, whose main period appears to be around 5.7 years with shorter periods of 150 to 300 days superimposed. The star has a peak magnitude of 0.2 in 1933 and again in 1942. At minimum brightness, as in 1927 and 1941, the magnitude may drop below 1.2, a difference in light intensity of about two times”. [Solstationweb] This star is a red supergiant. If it was to replace our Sun, its diameter would extend between the orbits of Mars and Jupiter. Due to its closeness and angular diameter, it was one of the first extra solar objects to have its disk diameter measured. “The angular diameter of Betelgeuse was first measured in 1920-1921 by Michelson and Pease using an astronomical interferometer on the Mount Wilson 100 inch telescope”. [Betelgeuseweb] Recent Hubble images taken in 1995, reveal a giant “hotspot” on its disk. This bright area is some 2000 K hotter than the surrounding surface. As mentioned earlier, along with other stars in the Orion constellation, it’s thought that Betelgeuse was formed several million years ago from the same large molecular clouds that produced others in the neighbourhood. Evolution of this star has progressed rapidly due to its unusually high mass. The Hipparcos satellite has provided a distance of 430 light years, giving it a visual magnitude of -5.1 and a visual luminosity of 9400 times that of our Sun. It has been found that Betelgeuse is radiating mostly in the infrared region, emitting only 13% in the visible spectrum. Current research into this star has shown radio telescope images of giant convective plumes that transport gas from the surface into its upper atmosphere. Again the Hubble telescope, imaging in the UV region, shown hot gas in the stars atmosphere at twice the surface temperature. More recent observations suggest that material may be condensing in the lower “cooler” levels of the atmosphere and then propelled outwards by intense radiation in the higher regions of the atmosphere. These observations are helping to show us how red Supergiants provide a source material for
the interstellar medium. The future for this star will probably see it fusing the higher elements up to iron and then collapse and explode as a supernova. [Solstationweb]

Differences in apparent brightness and distances from the Earth can readily be made by comparing Beta Orionis, Rigel and Kappa Orionis, Saiph. These two stars are approximately the same distance from Earth (see Table 1) and yet Rigel is clearly the brighter of the two. However, Rigel is classified as a blue Supergiant star of 17 solar masses, shining at 40 000 times that of our Sun and a surface temperature of 11 000 Kelvin. With this rate of energy expenditure, Rigel is fast approaching the end if its life as its core has depleted its hydrogen supply. [WikRigelweb]

On the other hand, Saiph is one of the hotter stars in the constellation, with a temperature of 26 000 Kelvin, placing it in the B1 class of supergiants. Luminosity is 65 000 more times than that of our Sun. So both Saiph and Rigel are blue Supergiants at approximately equal distance from us and yet Saiph is quite noticeably dimmer. From what we have read, Saiph should clearly be the brighter due to its hotter surface temperature. The reason it is noticeably dimmer is due to its higher temperature; with more energy available, much of its light is radiated as invisible ultraviolet light and not as visible light that we can perceive with our eyes. Again with this furious rate of energy usage, and like other stars in this constellation, Saiph is nearing the end of its life with hydrogen fusion not occurring in its core. [Saiphweb]

Similar to Saiph, Gamma Orionis, Bellatrix, is another blue-white Supergiant in the B2 class at 21 500 Kelvin. At a distance of 240 light years, its luminosity is 6400 times that of our Sun with an appreciable amount of UV coming from its hot surface. The stars luminosity is mainly attributable to its high temperature and not its size. With the closer distance to Earth, Bellatrix is considered not to be associated (“born” from a common Orion molecular hydrogen dust cloud) with other stars in the Orion constellation.

The future of Bellatrix will probably see it become an orange giant in the next few million years and then probably die as a massive white dwarf. [Bellatrixweb]
Alnitak (Zeta Orionis), Alnilam (Epsilon Orionis) and Mintaka (Delta Orionis) form the “belt” stars of Orion at approximately second magnitude. All three stars have similar colours, classes, and temperatures.

Alnitak’s 31 000 Kelvin surface temperature is more than 10 000 times more luminous than the Sun, again, most of this energy is been radiated in the UV portion of the spectrum and thus we cannot visibly see this luminosity. A turbulent surface sees gaseous wind flowing at 2000 km s\(^{-1}\) which collides violently with other gases producing X-rays that can be detected from Earth. Again, with other stars in this constellation, Alnitak is approximately 6 million years old, and hydrogen fusion has stopped in its core. A fate similar to that of Betelgeuse is predicted for the future of this star. Surrounding Alnitak are several more clouds of interstellar gas, one of which contains the famous Horsehead nebula. [Alnitakweb]

Alnilam is the brightest belt star radiating at 375 000 solar luminosities and a 25 000K surface temperature. Even though it is the furthest of the belt stars, Alnilam at 1340 light years from Earth is seen to be the brightest. At only 4 million years old, the hydrogen fusion process burning in its core shows signs of shutting down. Future events again see a future similar to Betelgeuse. [Alnilamweb]

Being the faintest of the three belt stars, Mintaka is seen as a “mount calibration” star by many amateur astronomers as it lies within a quarter of a degree of the celestial equator, which sees this star rising and setting almost exactly east and west. This star shows characteristics of the other two, although it is more well known for its complicated starry companions. At a quarter of a light year from Mintaka, a seventh magnitude star orbits the blue supergiant. In between this distance, another 14\(^{th}\) magnitude star orbits. Mintaka itself also has a close double. Mintaka is a class B at 30 000 Kelvin, while the other is a slightly hotter class O star. The pair are only “seen” through their spectrums and a slight dip in magnitude as one star eclipses the other. [Mintakaweb]

From this short tour of the Orion constellation, we see in the main, a group of
stars that seem to have been born from a common cloud of molecular hydrogen gas and dust. Through gravitational interactions, large hot stars have formed with much higher energy output than that of our own Sun. Where our Sun’s life is relatively sedate and measured in billions of years, Orion’s star life is measured in just a few millions of years. This sees a future that is astronomically very short. Much can be learnt about stellar life from these relatively close stars. Traditionally, we have used instruments that provide us with information on elemental stellar atmospheric properties and composition by examining stellar spectrums, but now major space telescopes such as the Spitzer, which “looks” in the infrared region and the Compton telescope which images in the X-ray part of the EM spectrum are now turned to this region. While these stars are dying, Orion’s Great nebula provides us with a front seat view to the birth of new stars.
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