

Betelgeuse, Johannes Bayer and Purkinje effect

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Abstract

Betelgeuse is the alpha of Orion, and normally alpha means that it is the brightest star of its constellation. Johannes Bayer was the first in 1603 to order the stars with the greek letters in sequence of luminosity. Are several the cases when the alpha is less luminous than beta, and many more cases in which beta is dimmer than gamma et cetera. Why these incongruences?

One of the reasons is because some stars are variable and this is the case of Betelgeuse, but other is the Purkinje effect which made the red luminous stars more brilliant to the naked eye, when we stare at them.

Statistics on Betelgeuse

Its variability become recently a worldwide case with its deep minimum down to visual magnitude of 1.4, never registered in the last century. There are various harmonical components of its variability with the main ones of 1.2 and 5.9 years. Alternately every 5 cycles of 1.2 years a larger maximum or a deeper minimum is attained.

From a statistical point of view the probability to find in 1603 Betelgeuse at its absolute maximum, larger than Rigel, beta Orionis, is 38/600

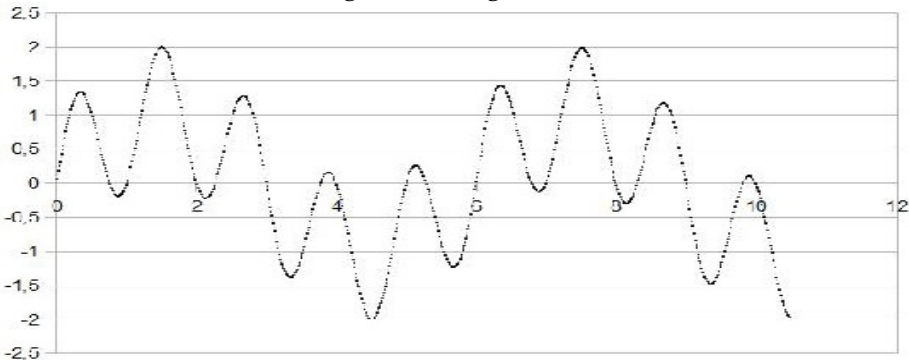


Fig. 1 Oscillations of two sinusoids with the main periods[yr]of Betelgeuse
This is a graphic of two sinusoids of period 1.2 and 5.9 years with equal intensity (same power in the Fourier spectrum). The time in which the



curve peaks above 1.5 is 38 parts over 600, i. e. 6.3%.

The choice of the "top 0.5 level" is due to the normal amplitude of the oscillations of Betelgeuse: from 2 to -2 is equivalent to 1 whole magnitude, from 0 to 1. Since Rigel is 0.13, the extension of 0.13 magnitude over 1 corresponds to 0.52 over the range of 4 [-2, 2], then the choice to evaluate the top 0.5 of the curve of figure 1.

The probability that casually Johannes Bayer evaluated Betelgeuse brighter than Rigel because actually it was so is 6.3%.

Frequency approach of probability

Using the frequencial approach of Bruno De Finetti, we can compute the probability to find Betelgeuse at its maximum by analyzing the last 8 years of its light curve, and the whole AAVSO light curve of alf Ori. The results are: 8 years V-band data (VOL/AAVSO 647 data):

8 years visual data (SGQ/AAVSO 602 data):

Both results are in the range of 5-10% of probability to occur by chance in 1603 when Bayer published his Uranometria.

Other odd cases

Beta Scorpil with Delta Scorpil: beta 2.5 vs delta 2.3 average and 1.8 at maximum luminosity. Delta is variable with 11 years period due to the orbital period of the companion. This case shows a "permanent error" not due to the color, since Beta and Delta are both white.

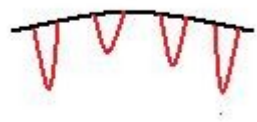
Sebastian Otero discovered in 2000 the variability of Delta Scorpil.

Alfa and Beta Geminorum are actually inverted in order, with Beta 1.16 and Alfa 1.58.

Purkinje effect

Staring at the red star it appears brighter at increasing staring time (up to a certain limit).

To avoid that effect it is recommended the quick glance method (Waagen, 2020)



The brightness of Betelgeuse at its normal luminosity is of 0.45 mag. Could have been it evaluated larger than the blue Rigel of 0.13 mag, during the luminosity assessment made by Bayer for Orion?

The probability that Betelgeuse would have been brighter than Rigel exactly in the assessment phase made by Bayer is very low, since, Betelgeuse does not exceed its average magnitude very often.



Fig. 2 Orion constellation by Johannes Bayer, with alf Ori at left hand side.

Conclusions: it is more probable that the Purkinje effect is the main cause of the listing of Betelgeuse as alfa Orionis, than the star was exactly at its absolute maximum, which occurs only for th 6.3% of the time, see also figure 3 of 90 years of light curve of Betelgeuse.

References:

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https://en.wikipedia.org/wiki/Purkinje_effect



AAVSO database on alf Orionis www.aavso.org

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Alpha Orionis (Semiregular) 1911-2001 (10-day means)

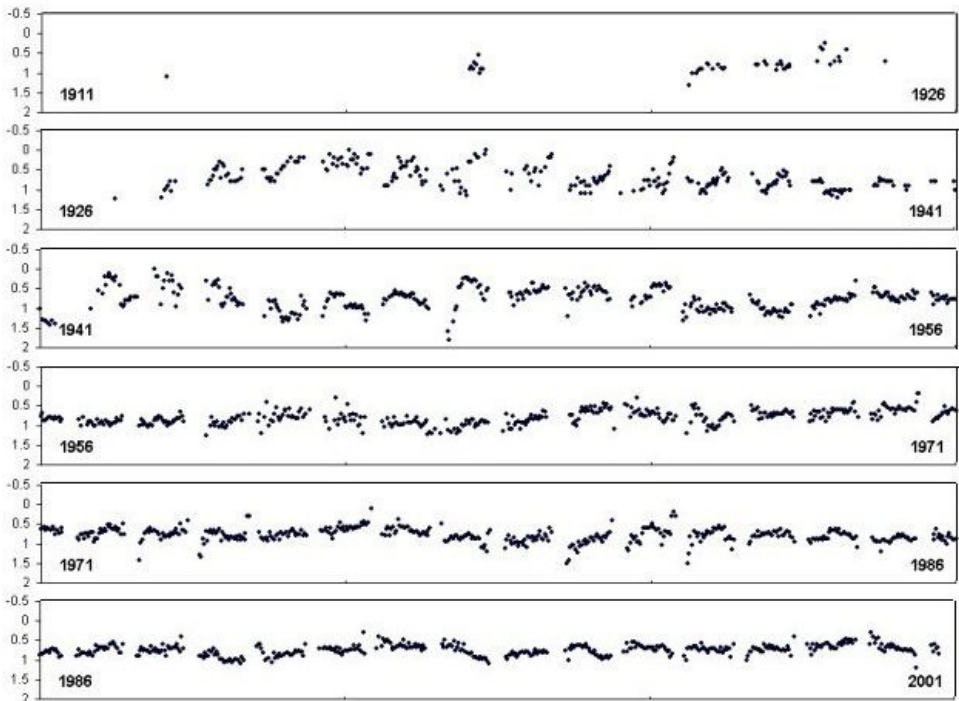


Fig. 3 Betelgeuse light curve during 90 years: it is found brighter than Rigel only around 1930 and 1940, say less than 1/9 of the times (Figure from M. Kidger, on AAVSO data)

