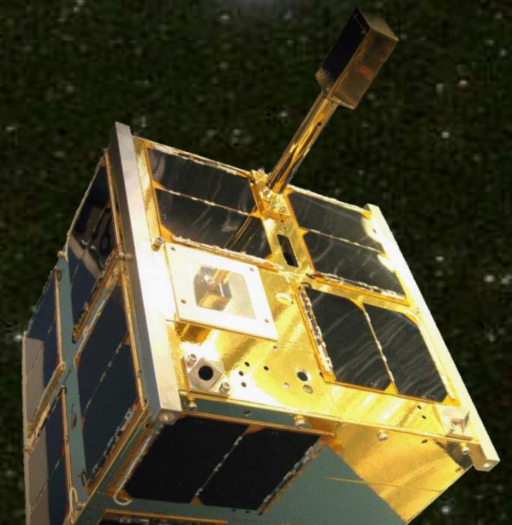
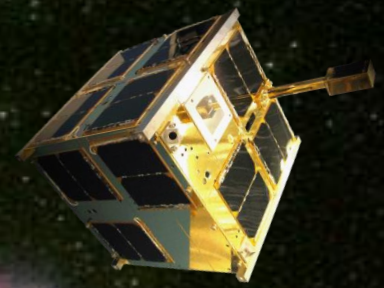
BRITE & Long-term Ground-based Photometry of the Pre-SN II Red Supergiant - Betelgeuse





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EWASS-2017
SS17 Science with BRITE
June 26, 2017 10 AM

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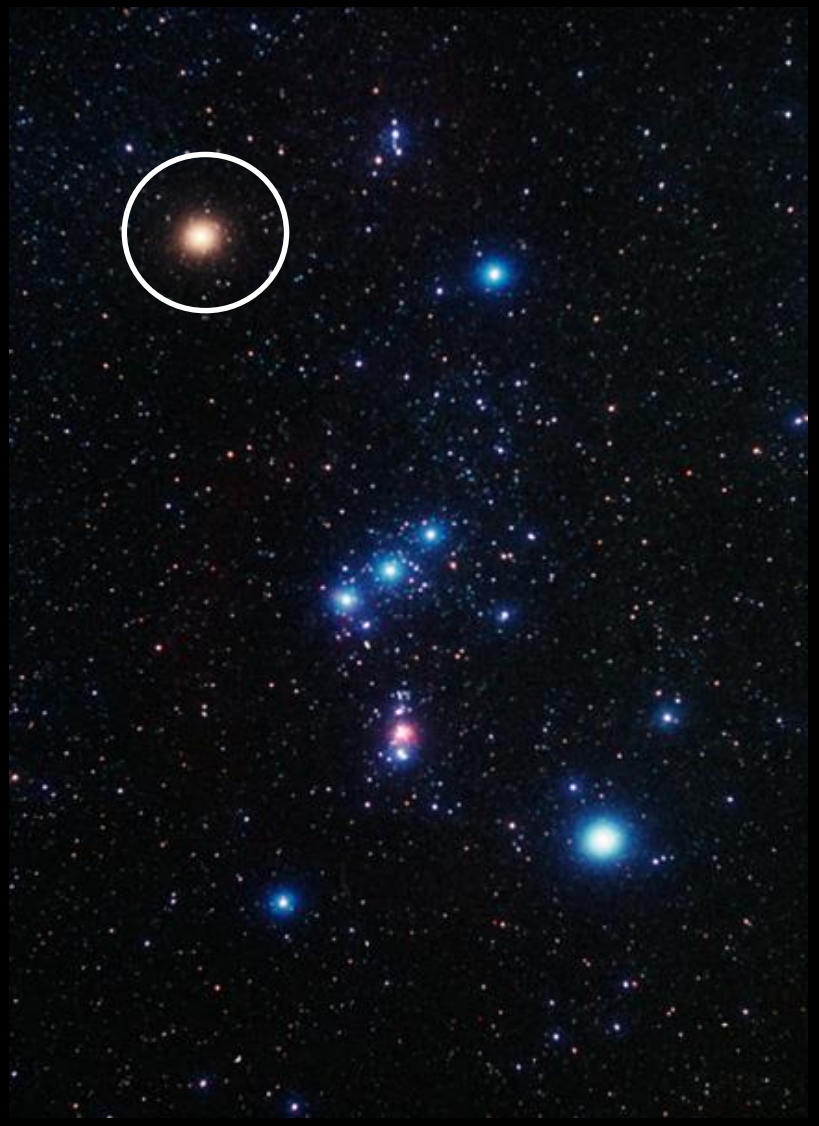
Outline

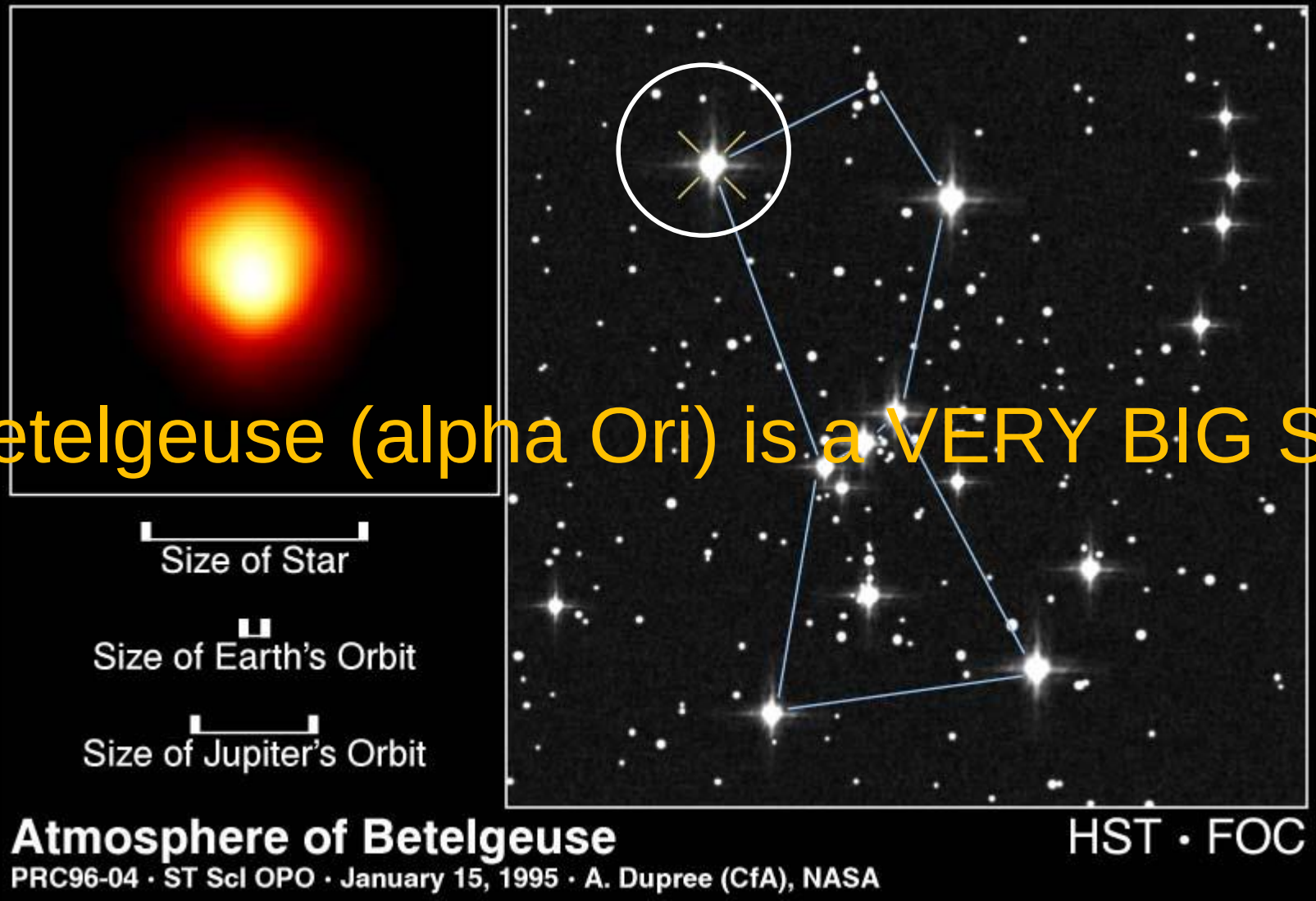
i. Properties of Betelgeuse (alpha Ori)
ii. Long-term Photometry: 1930-2017
iii. BRITE Photometry 2013/14 - 2016/17
iv. Results of the Photometry Analysis
v. Some Conclusions

α Ori (Betelgeuse) SN II Progenitor

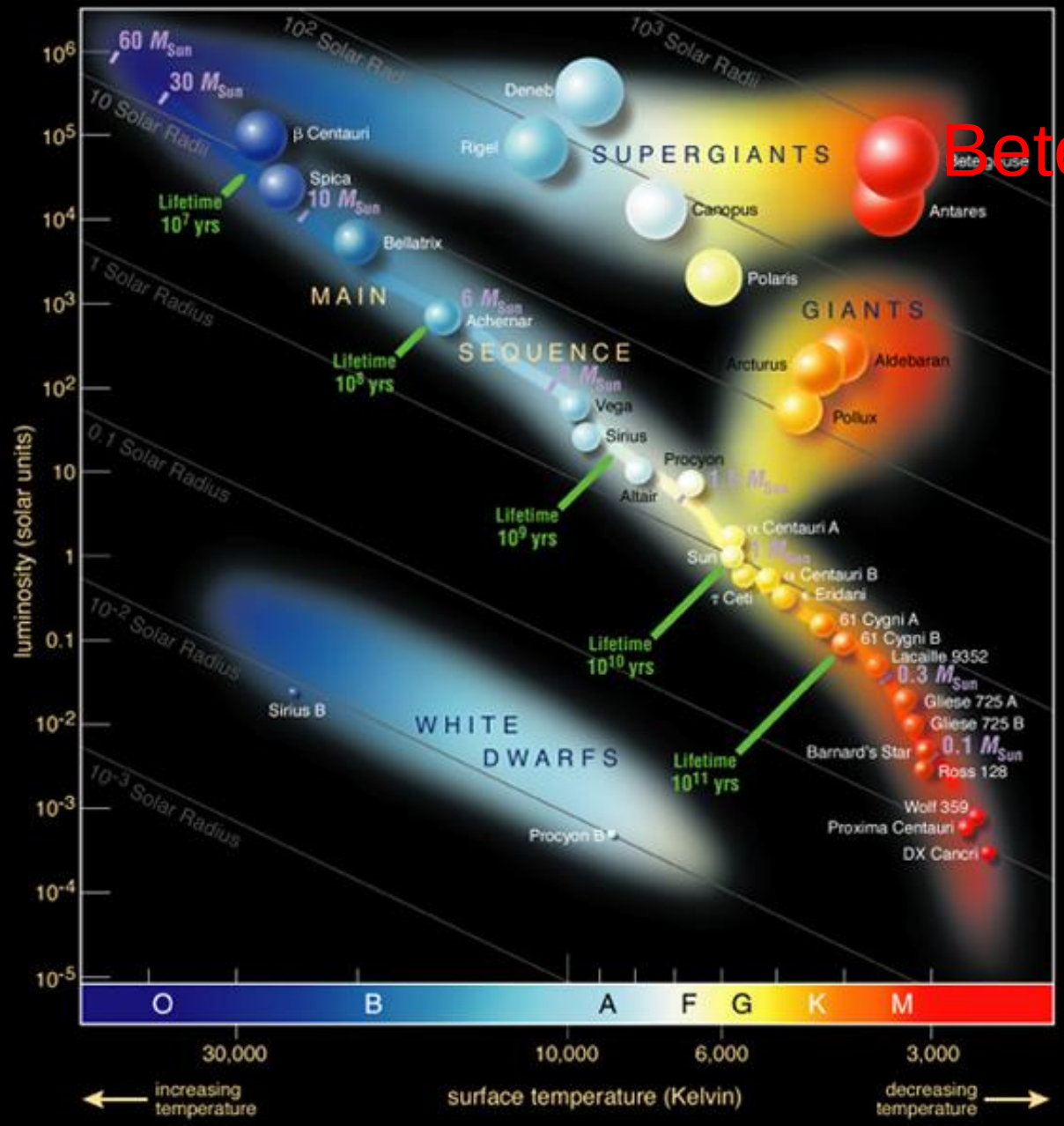


- Semi-Regular Pulsator – timescales of months to several years (W. Herschel discovered variability in1840)
- Spec. Type: M1.0 - 2.0 Iab
- mv ~ +0.2 – 1.0 mag
- d = 222+/-41 pc = 724 Ly (Harper et al. 2017)
- Mass = ~12 -18 $M_\odot$ Mean Radius: ~1200 $R_\odot$
- Luminosity ~100,000 $L_\odot$
- Age = 8 +/-1.5 Myr
  - Photometry at Villanova since 1982.
  - BRITE: 2013-2017
  - Use light variations to probe the interior of this supergiant, progenitor of SN II.

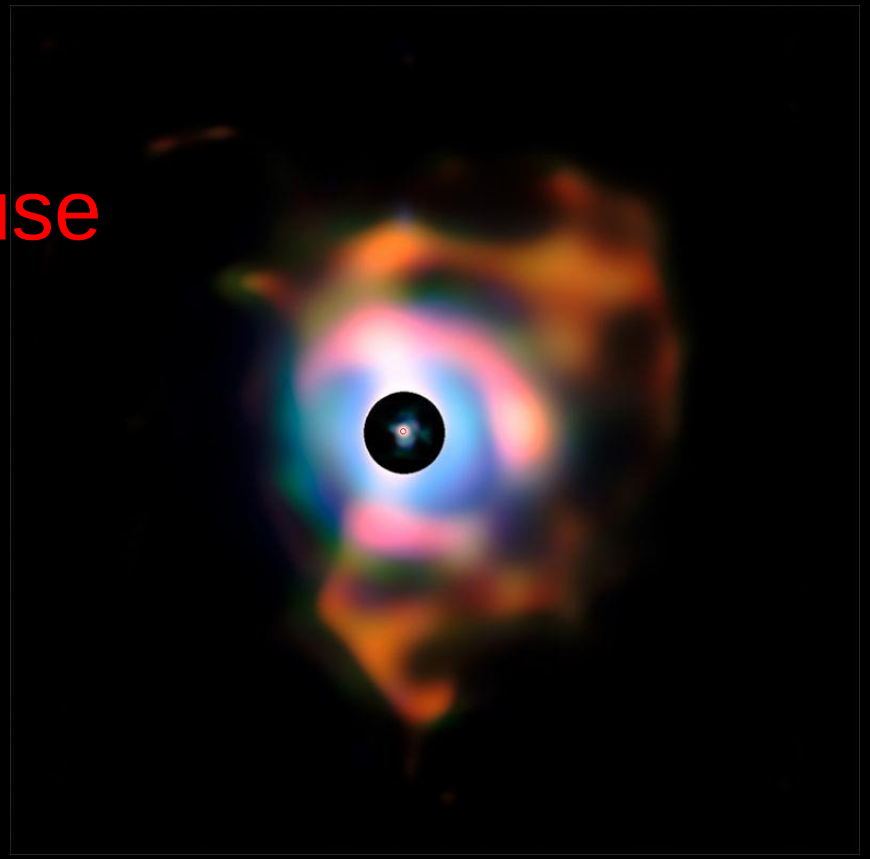
Betelgeuse (alpha Ori) is a VERY BIG STAR



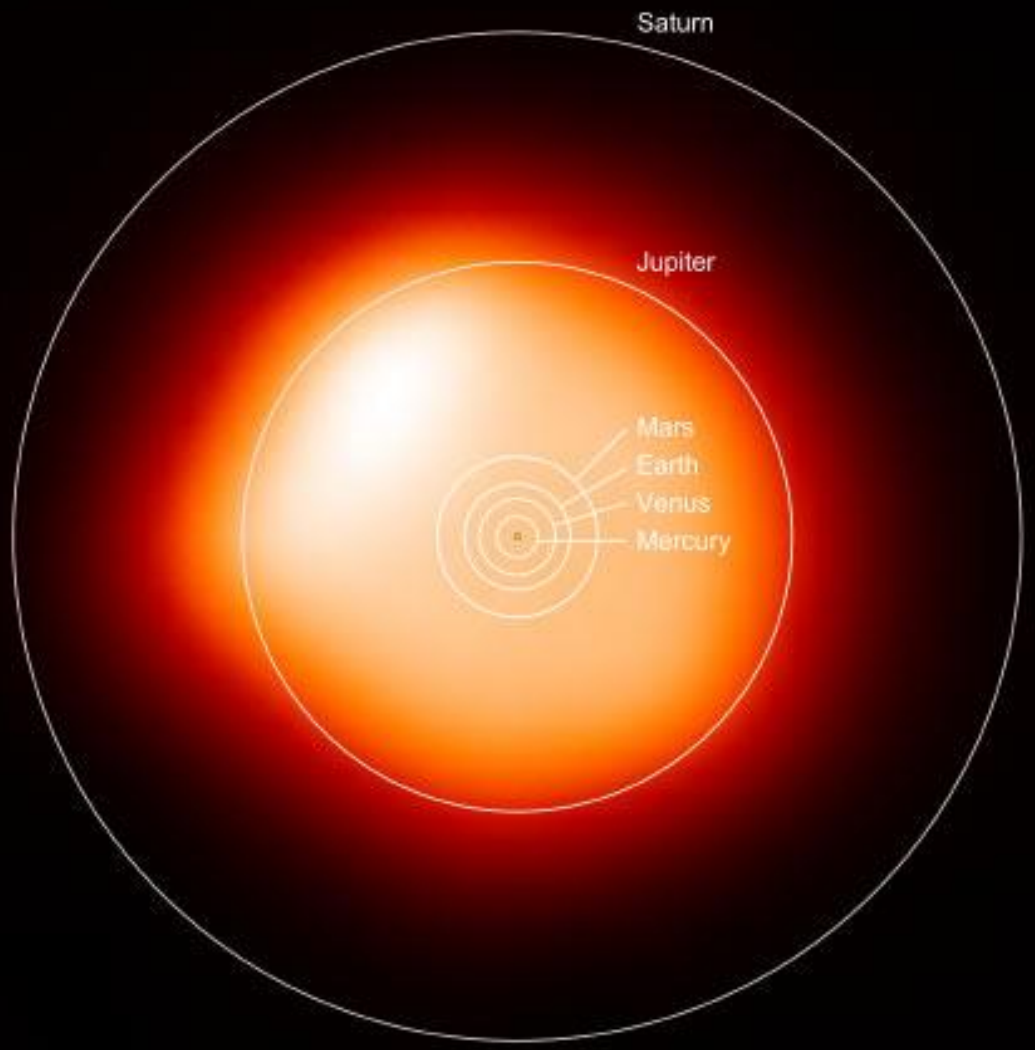
Hubble Faint Object Camera image of Betelgeuse. The Hubble picture reveals a huge ultraviolet atmosphere with a mysterious hot spot on star's surface. The enormous bright spot, twice the diameter of the Earth's orbit, is > 2,000 K hotter than the star's surface.



Betelgeuse



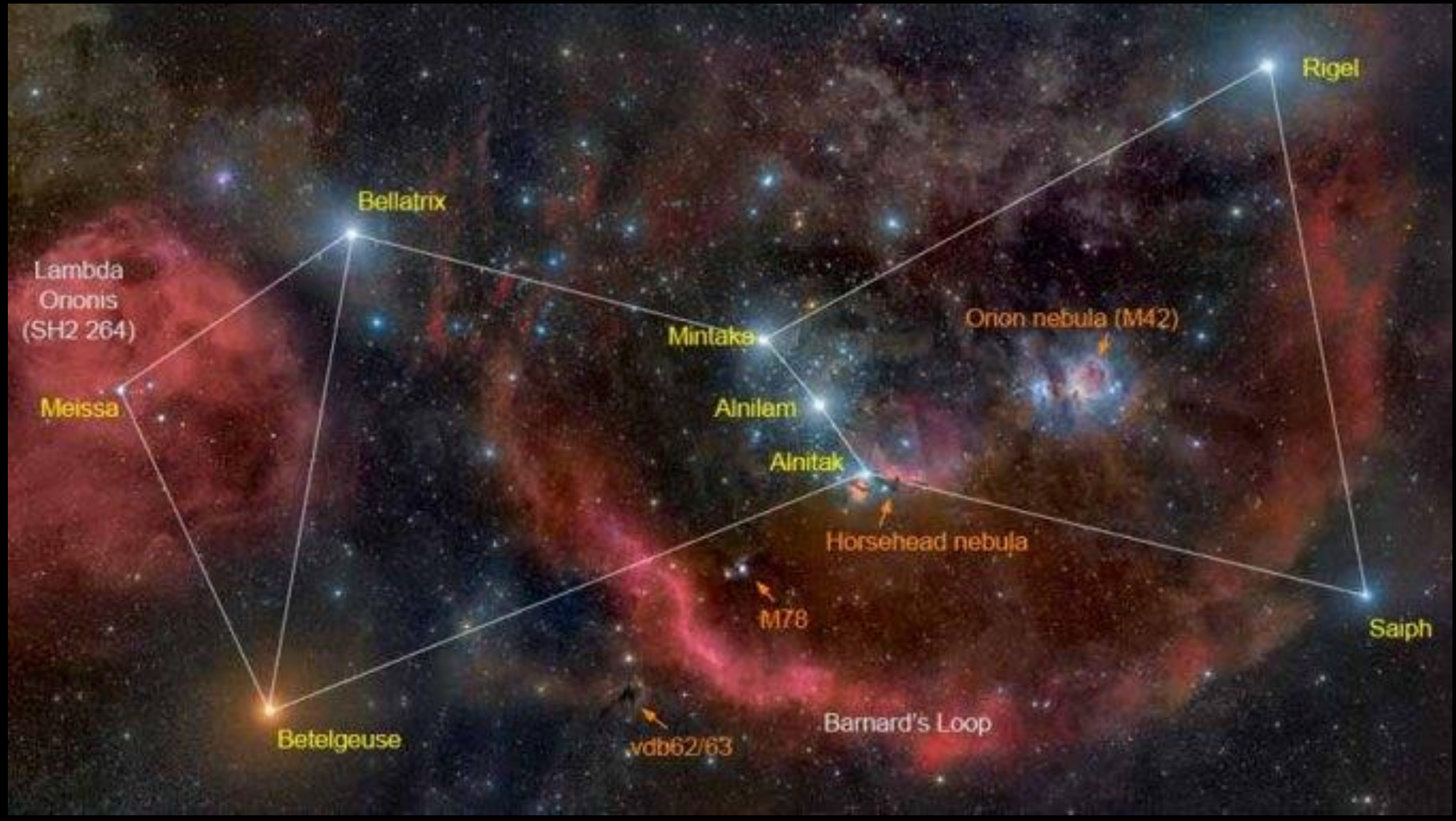
Infrared image from the ESO's VLTs shows complex shells of gas and dust around Betelgeuse - the tiny red circle in the middle is the size of the photosphere.



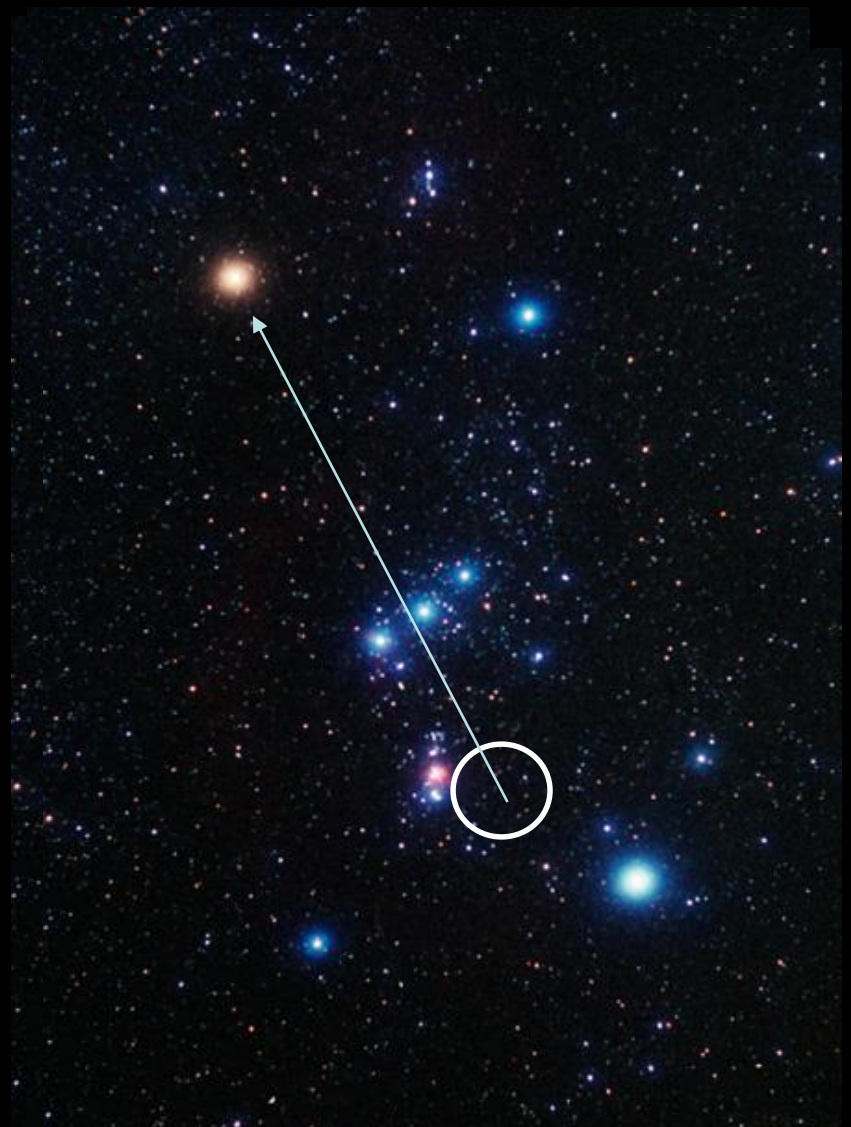
Recent millimeter Image of Betelgeuse from ALMA showing bright spots and asymmetries in its shape. Image is superposed on Sun and solar system.

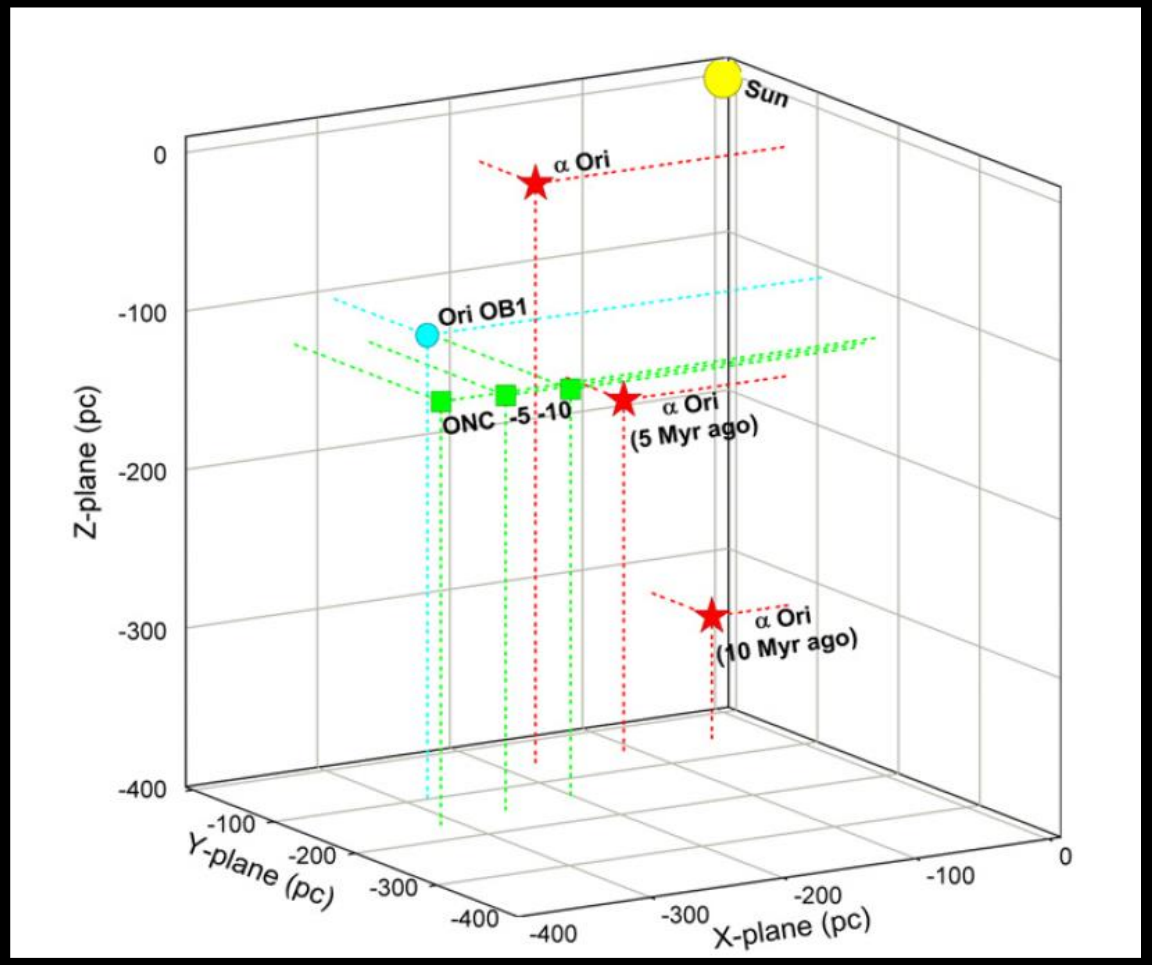
From O’Gorman et al. 2017.

Orion Region in the Infrared



Betelgeuse may be a runaway star from the Ori Nebula / OB1 region ~8 Myr ago

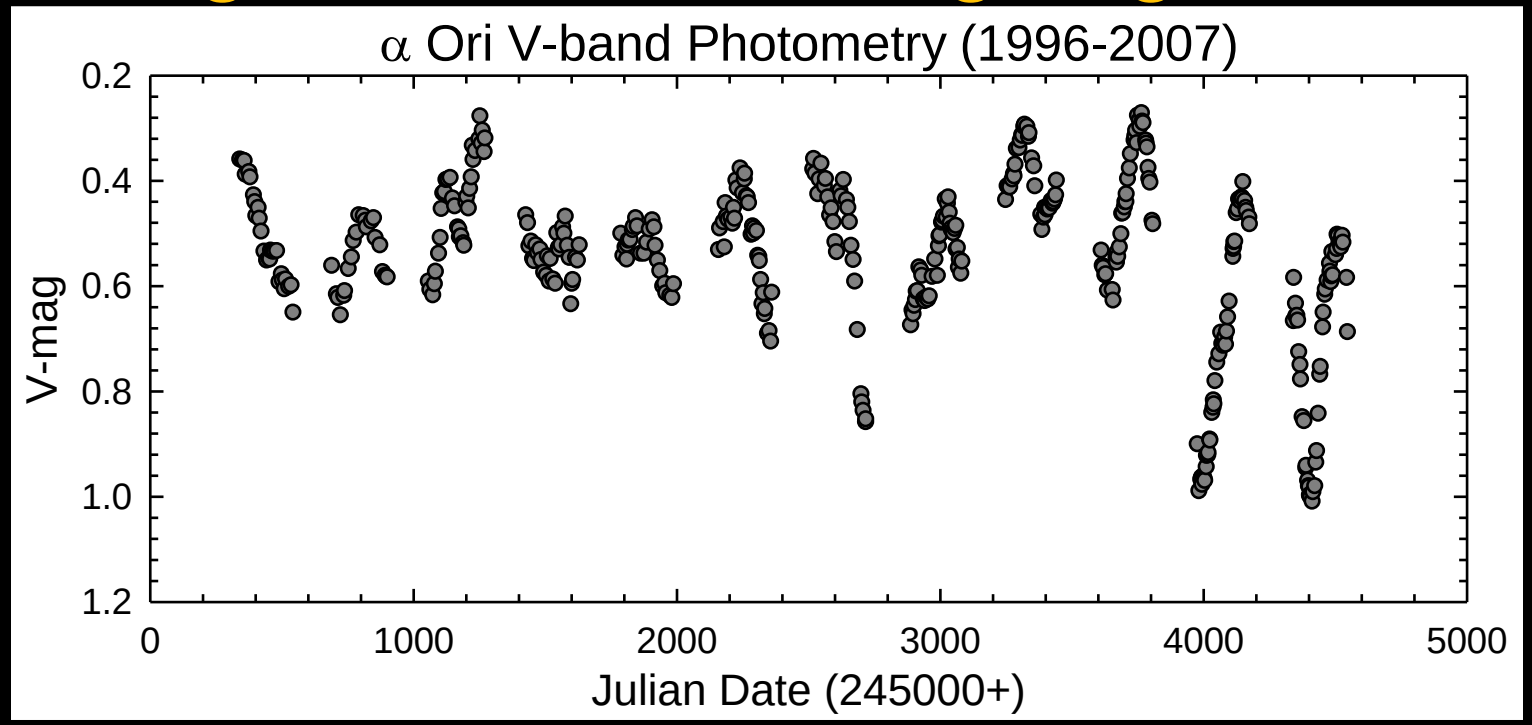




Harper, Brown, Guinan 2008 AJ. 135, 1430.

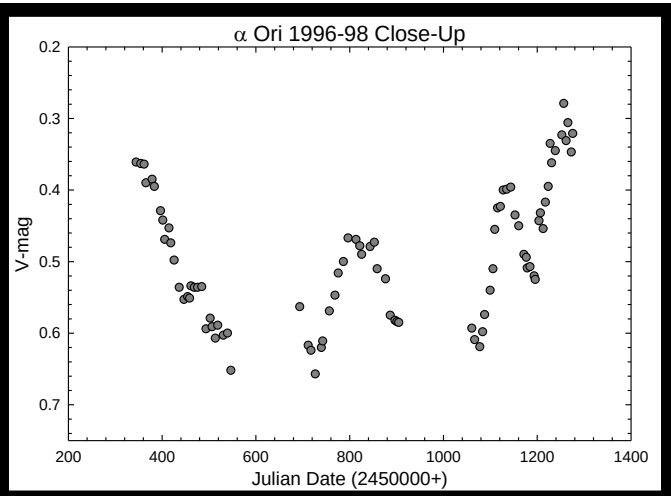
NEAR IR Spectroscopy of Betelgeuse with SOFIA
March 2014 (P.I. Graham Harper)

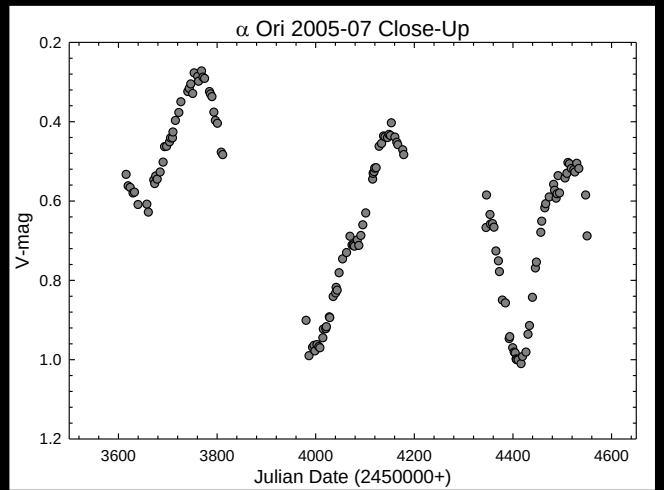
Examples of the Semi-regular Light Variations of Betelgeuse from our ongoing Photometry

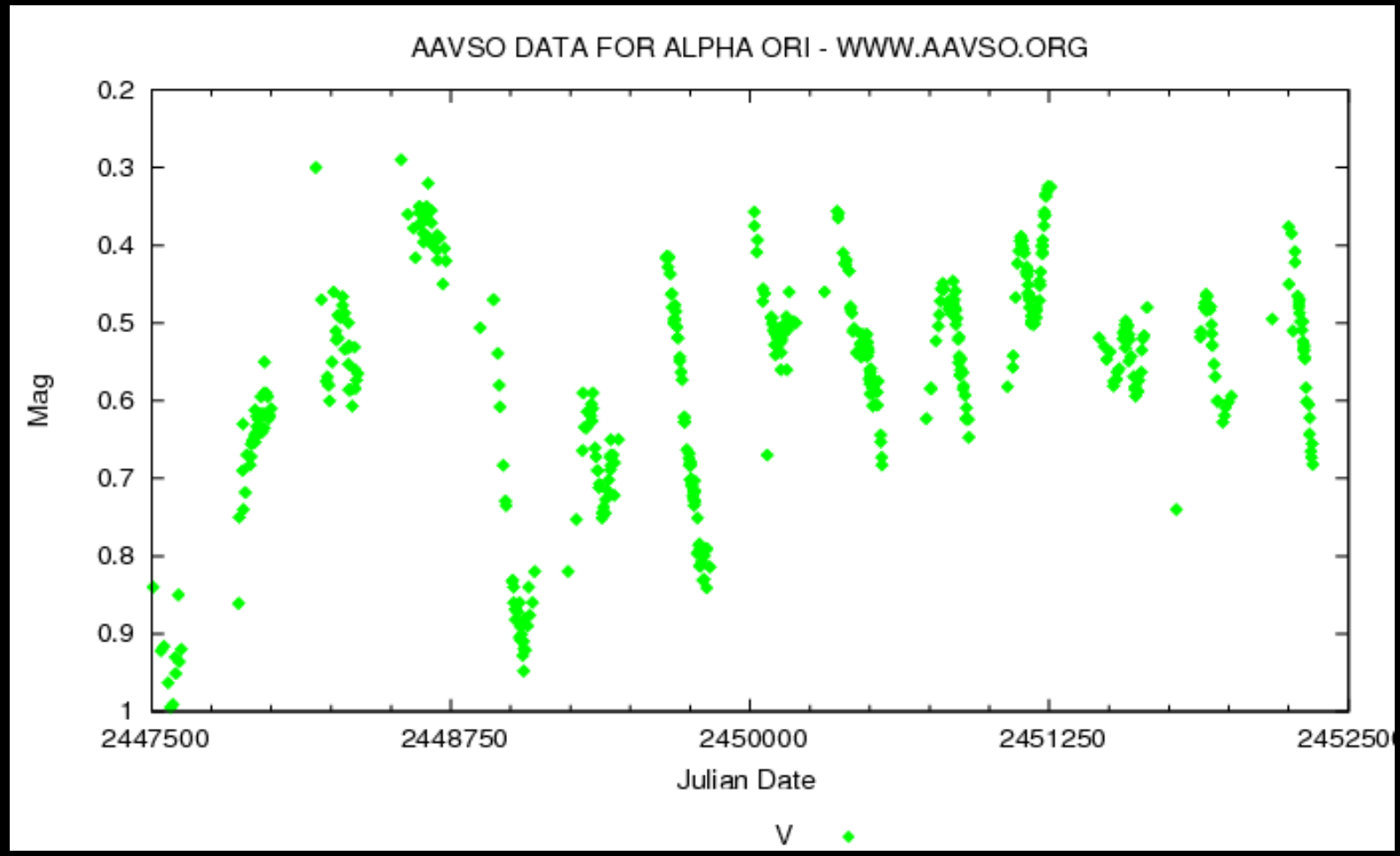


Left: Long-term V-band photometry of alpha Ori

Bottom: Close-up of two observing seasons.

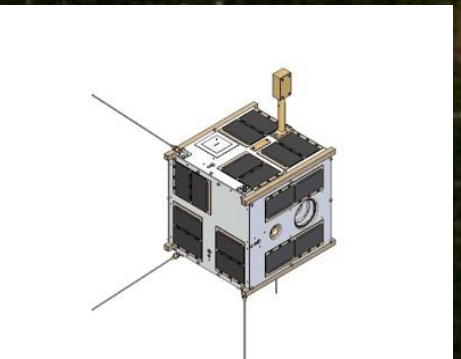






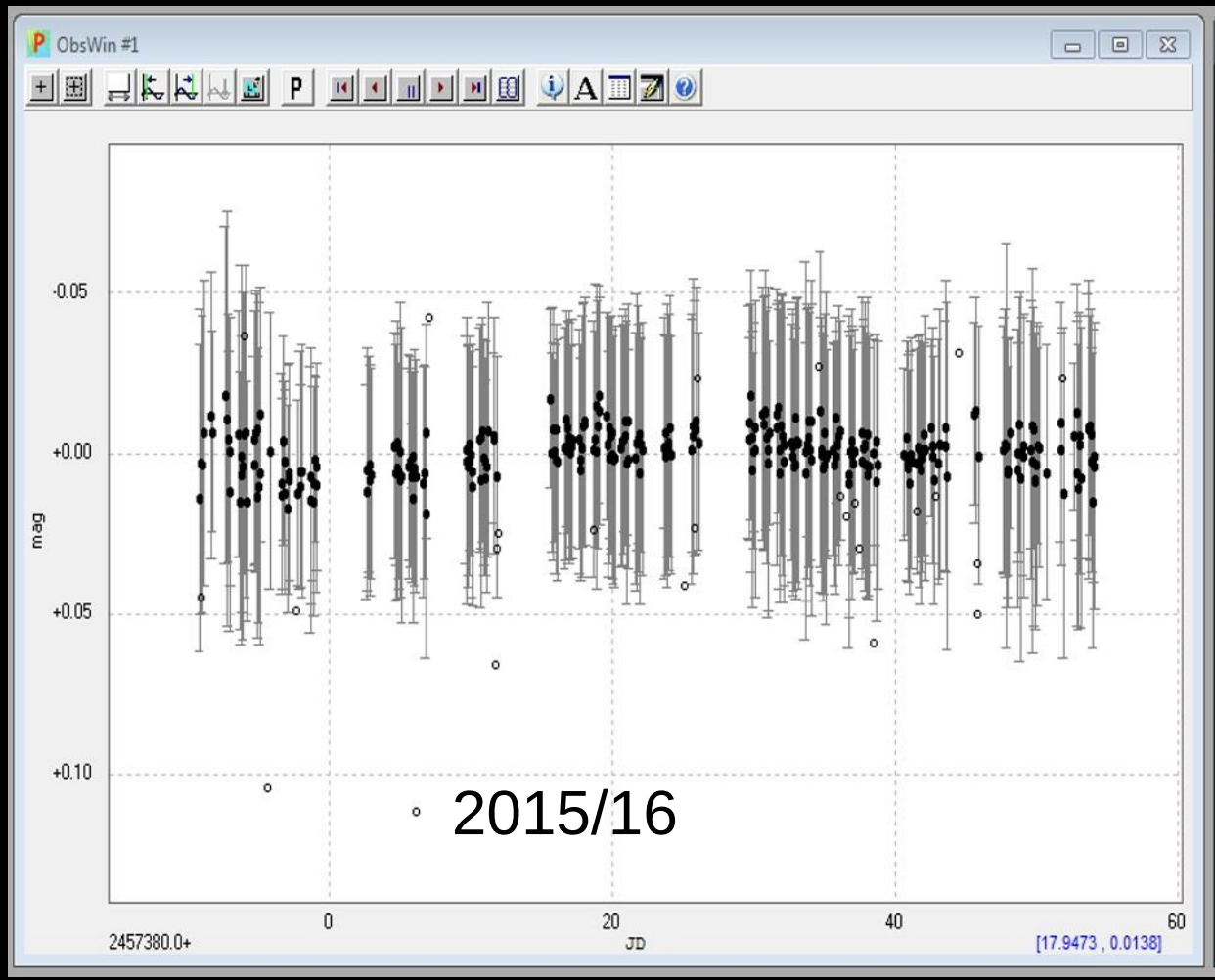
AAVSO V-band Observation of Betelgeuse (Alpha Orionis) from Dec 1988 to Aug 2002

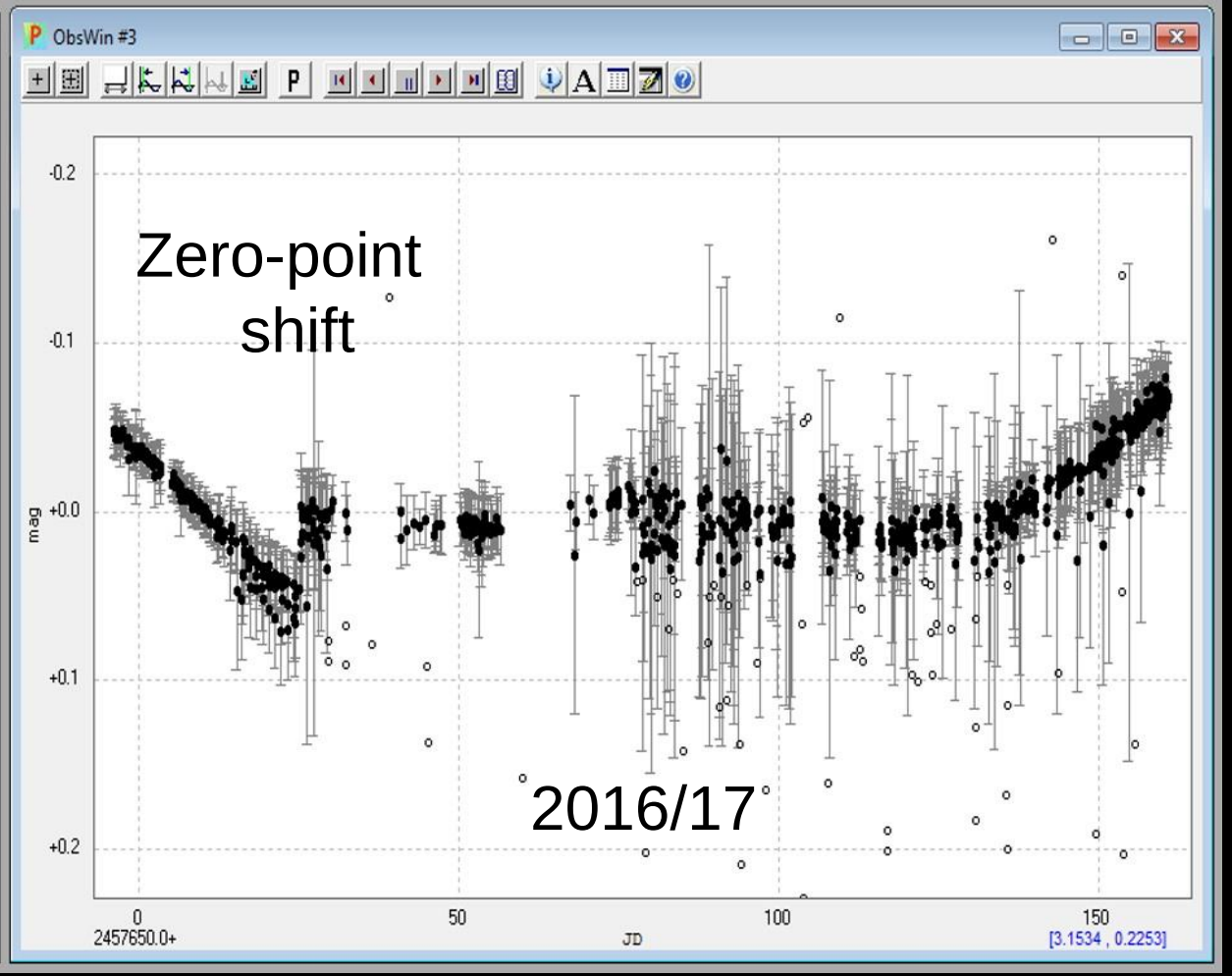
BRITE Observations of Betelgeuse were made during the 2013/14 through 2016/17 Orion Observing Seasons



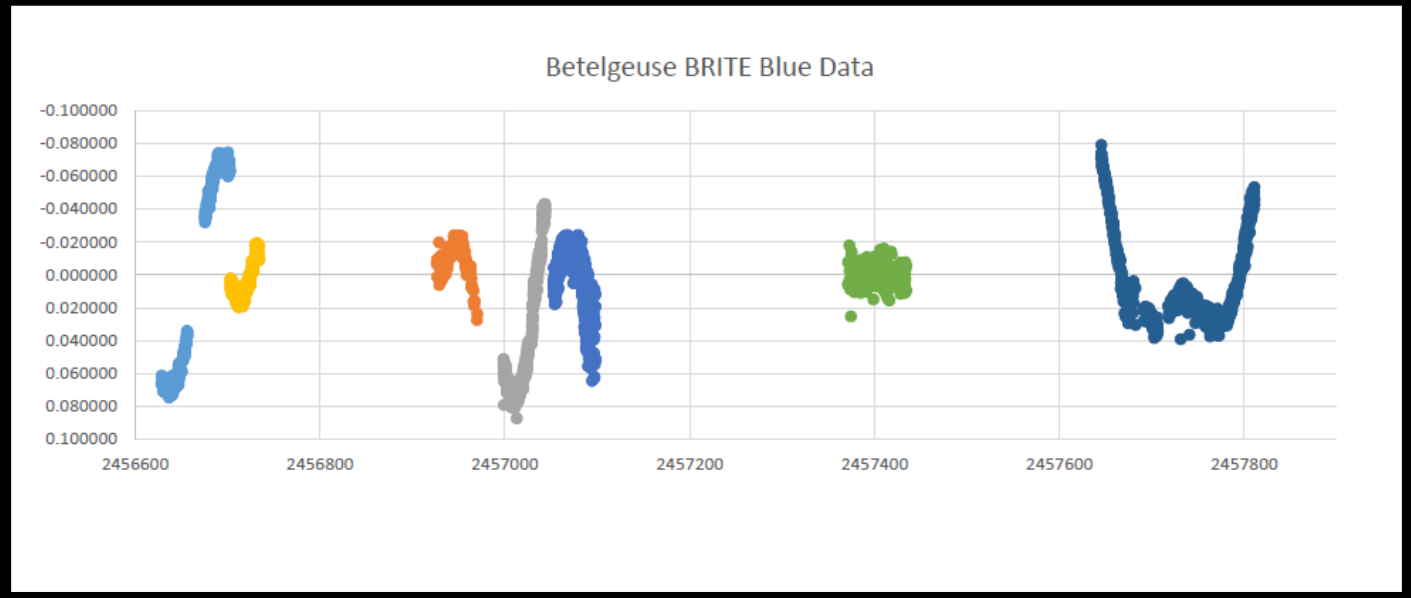
Partially Processed BRITE Photometry of Betelgeuse

From Andrzej Pigulski ---"this is real difficult star for BRITE"

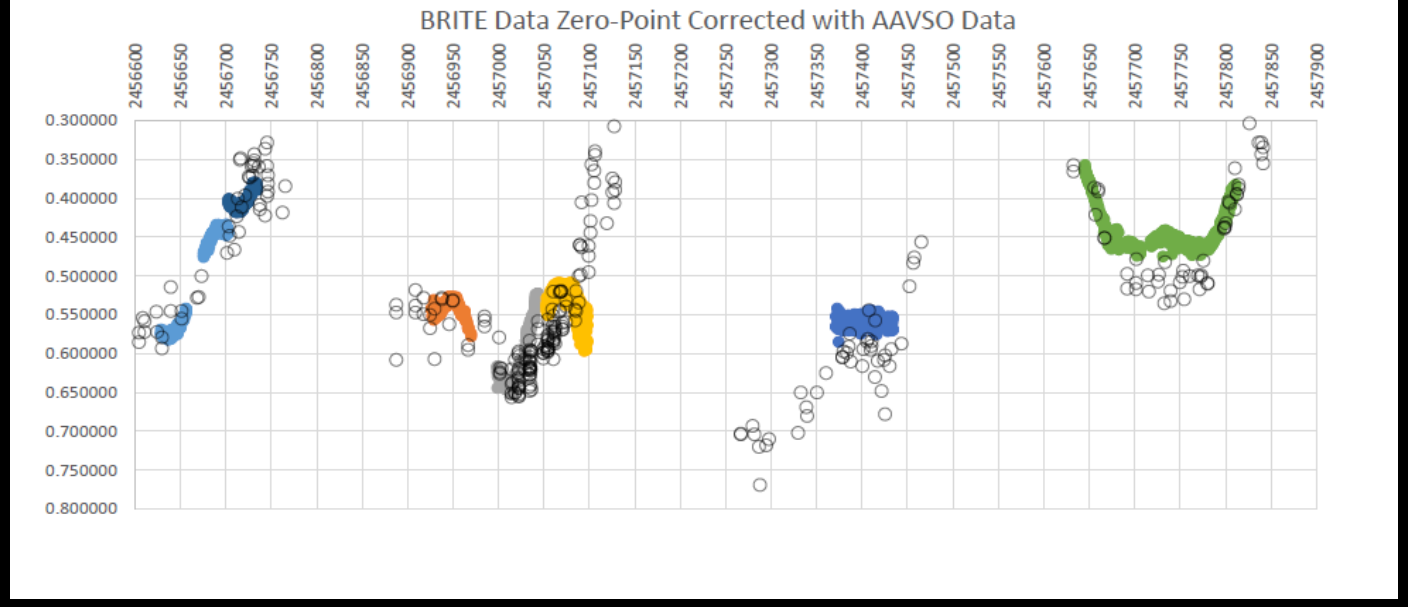




BRITE Photometry of Betelgeuse from 2013/14- 2017



Processed BRITE data with standard Detrending and other corrections applied

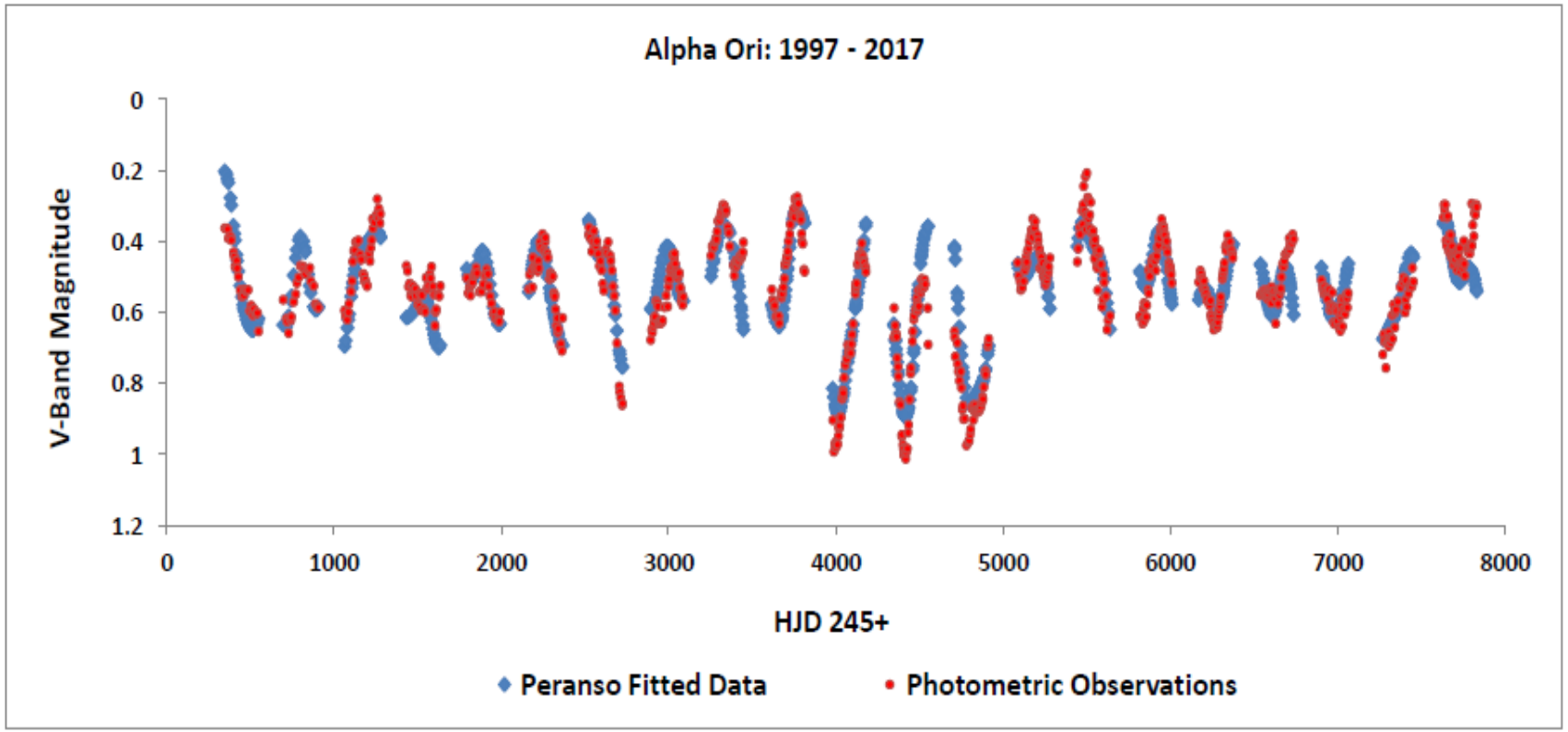


Same BRITE data: Normalized seasonally using AAVSO and our V-band photometry

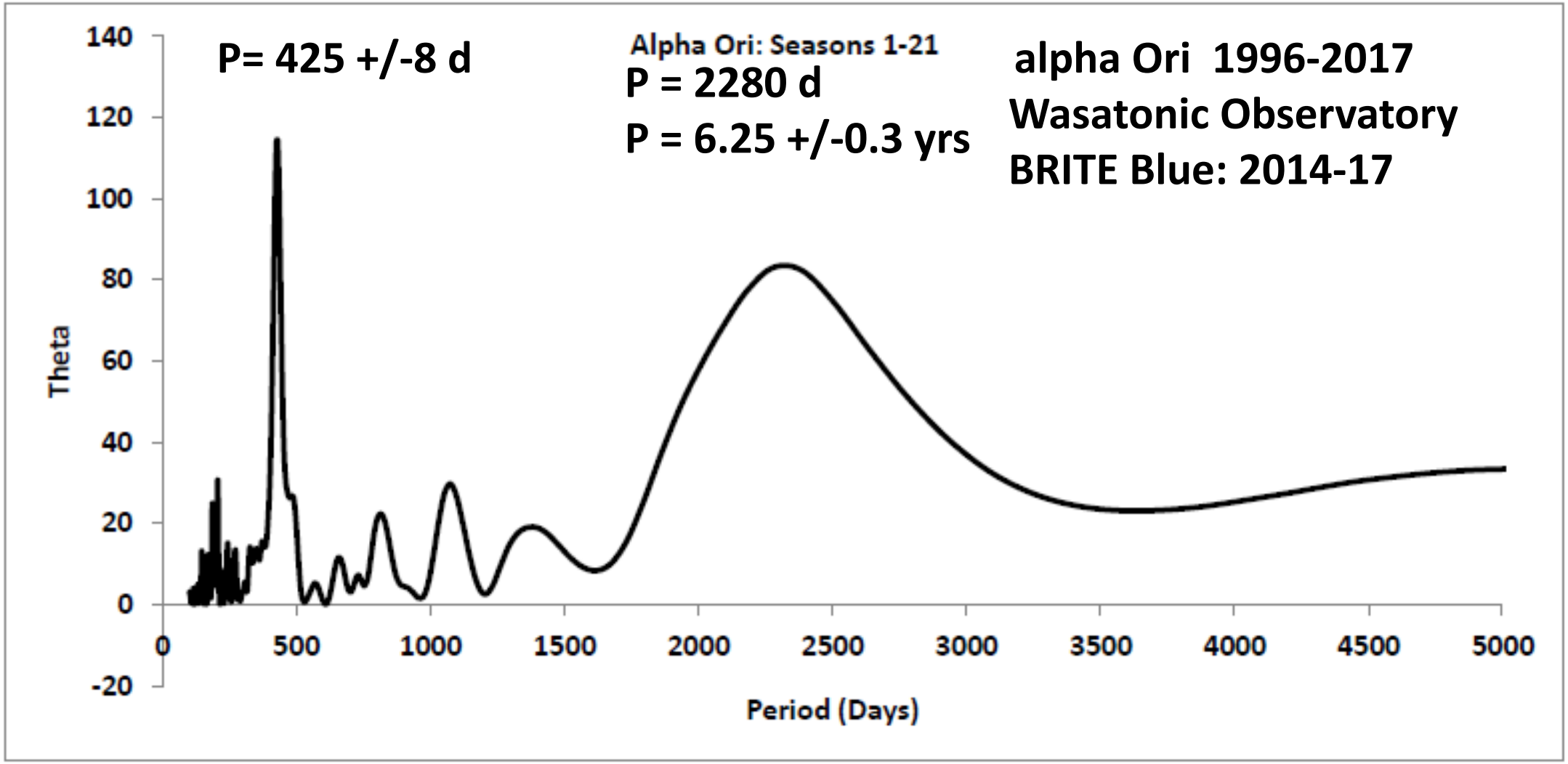
PERANSO POWER SPECTRUM FITS TO THE 1997 - 2017

OBSERVATIONS: 12 prominent periods were used in making the fit.

The dominant two periods were 425 day (theta =114) and 6.25 yr.(theta=79)



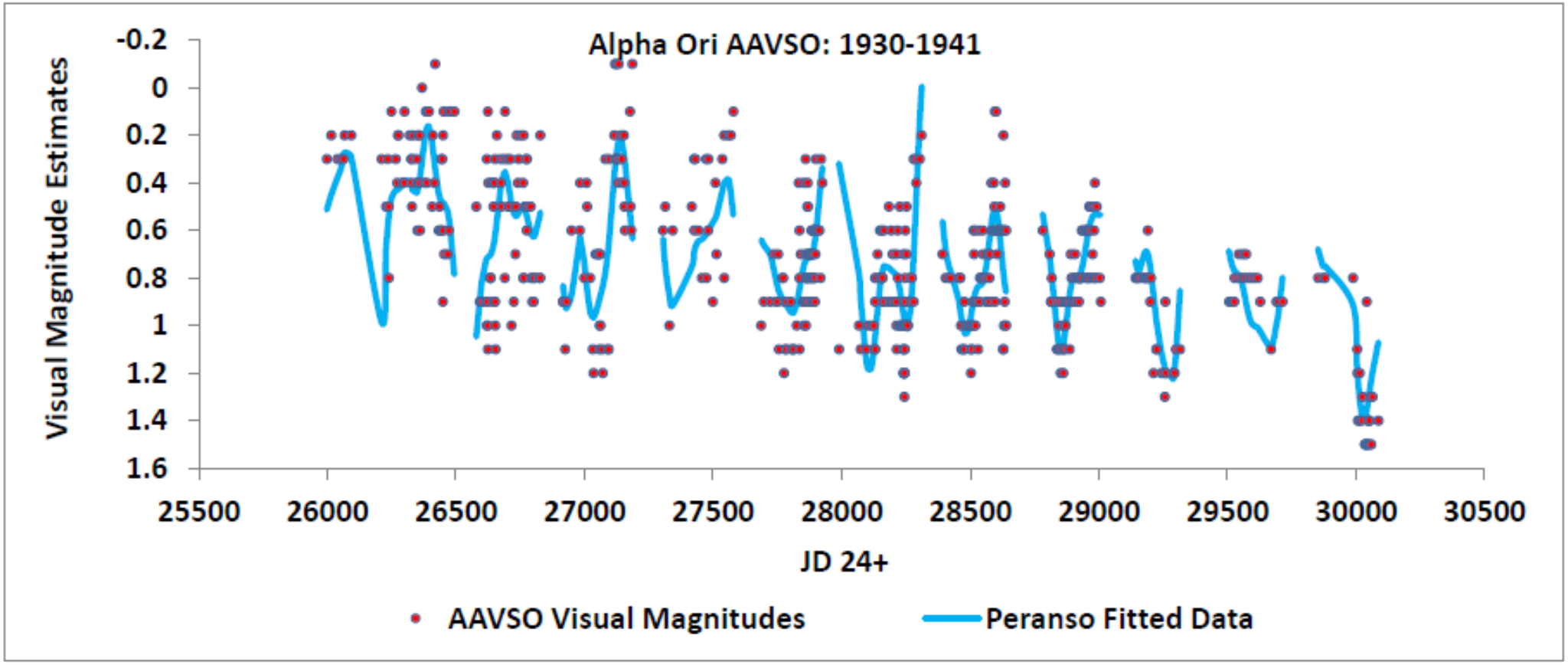
Period Analysis of Photometry from 1997-2017

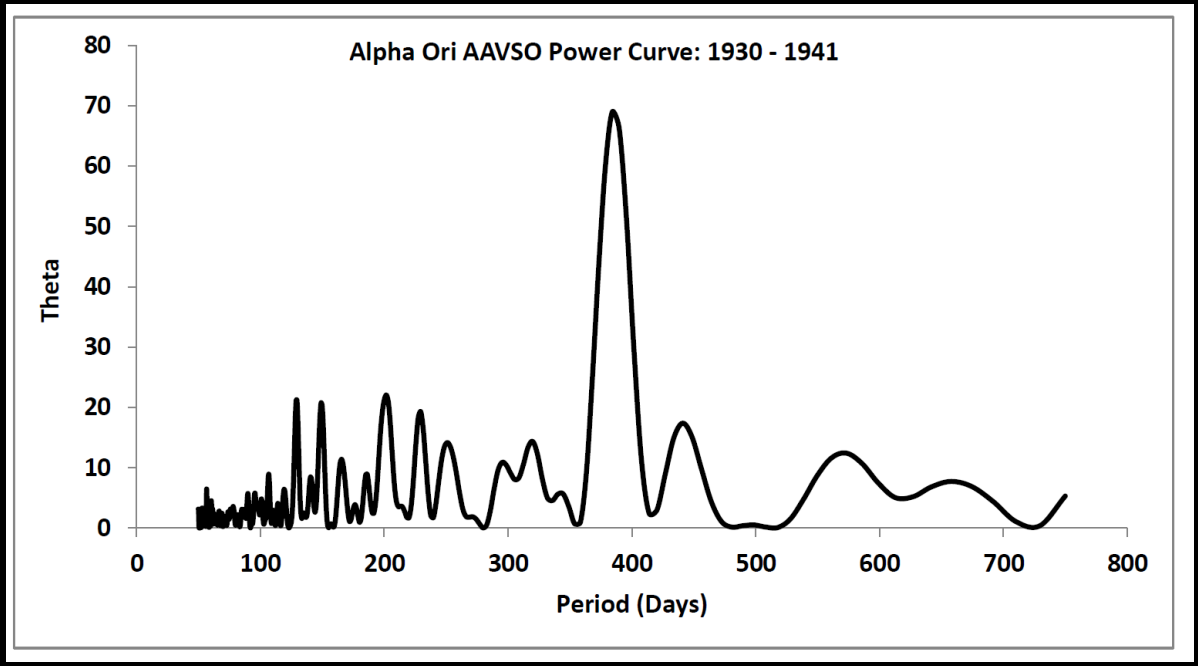


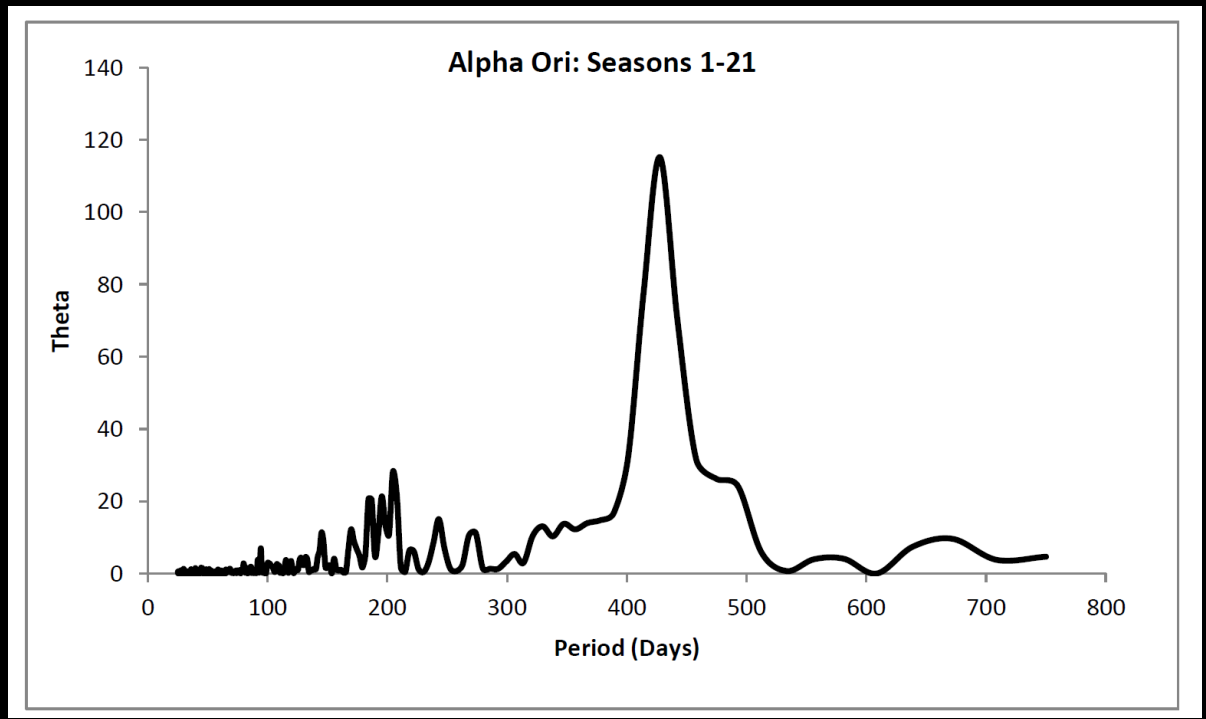
Most Prominent Periods returned from the Analysis of the 1997-2017 photometry

Periods (Days)	Power (Theta)
427	114
2280 (6.25 yr)	79
395	64
271	63
472	61
349	44
185	41
155	40
658	39
328	38
244	33

Analysis of the AAVVO 1930-41 visual Photometry
The two highest power returned periods are:
P’ = 385 d and P’’ = 5.78 yrs







Period Studies of Betelgeuse

Analysis of the AAVSO visual photometry from the 1920s -1940s indicates a primary Period = 384 +/-12 days with a power of Theta =70. (see plot to the left)

Period analyses of the V-band photoelectric data (including the BRITE data) from 1996 - 2017, yield a primary period of P = 428+/-9 days

If this is a real period increase, then the star is increasing in radius (less dense / longer pulsation period) & evolving rapidly towards the upper right (red) of the HRD.

SOME CONCLUSIONS

I. BRITE returned blue photometry (+/-11 mmag); zero point corrections applied using ground-base photometry

II. No flares or significant short-period variations seen in BRITE data

III. Analysis of photometry from 1920s-2017 indicates the light variations are driven by a long-term P'=5.78 yr (1920-40s); P' = 6.25 yr (1996-2017) and a P= 385-d (1930s); 426-d (1997-2017); If the pulsation period increase is real, this implies that the star's density is decreasing and thus its radius may be increasing (~7% over one hundred years).

IV. With the larger distance and luminosity indicated by

V. Harper et al. (2017), it is estimated that Betelgeuse could become a SN II anytime within the next 200,000 yrs.


In the future not too long from now on a cold Winter’s night…


THANK YOU!
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