

Astro Dynamics

Robert Vanderbei

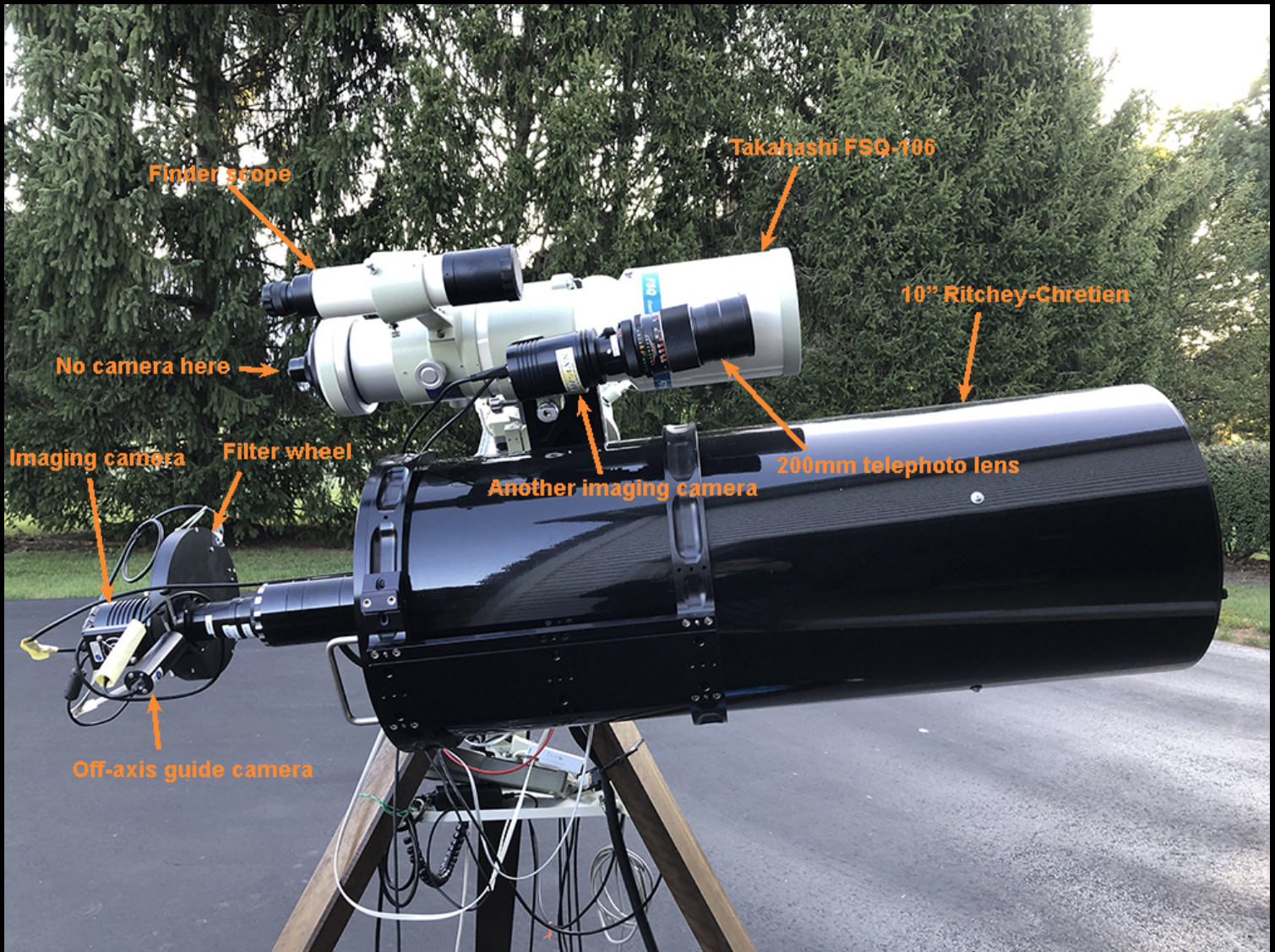
Lehigh Valley Amateur Astronomical Society
via Zoom

<http://vanderbei.princeton.edu>

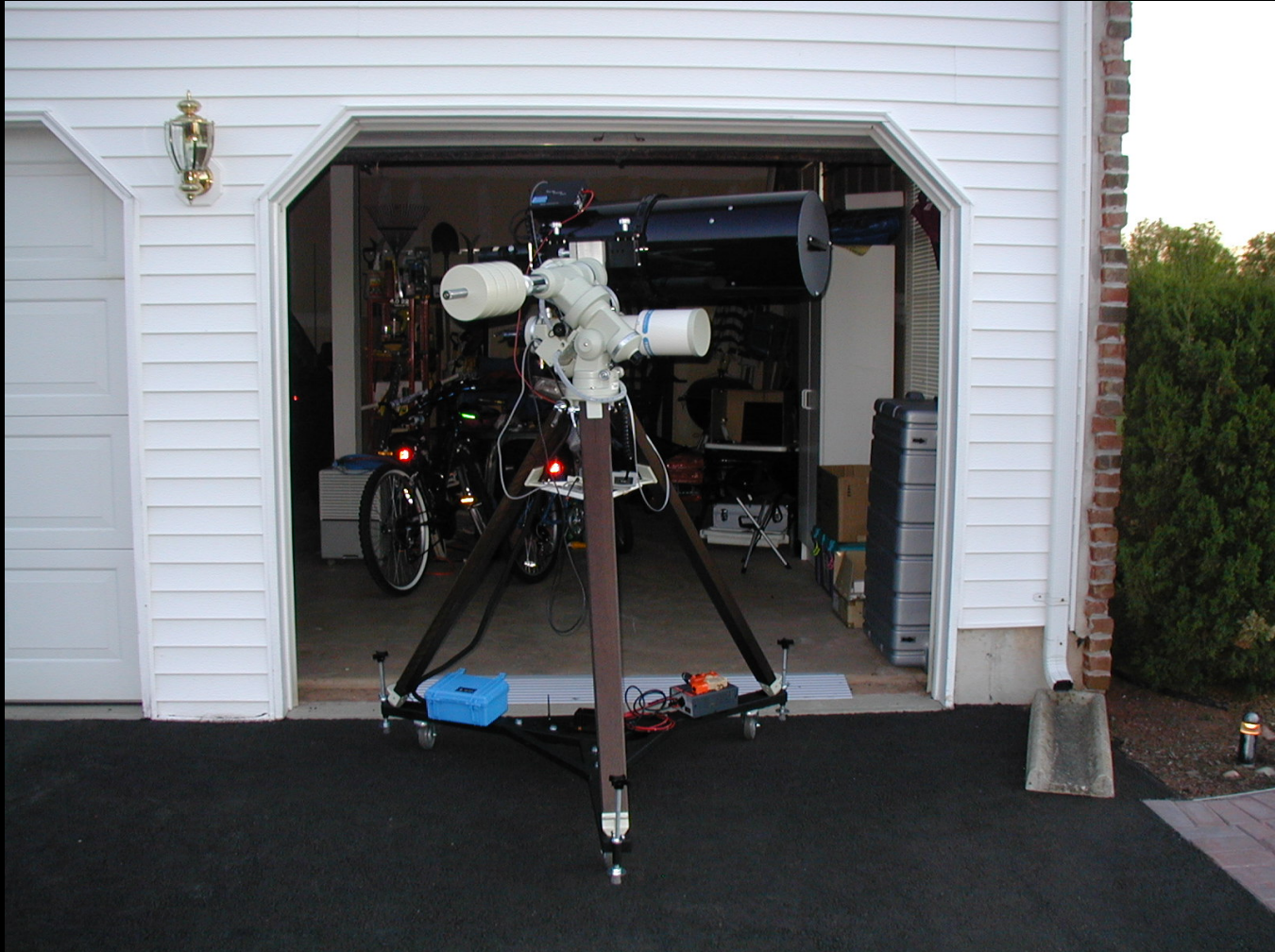
Astrophotography – A Temporal Perspective

- For those of us active in visual astronomy and/or astrophotography, one of the biggest downsides of the hobby is that after a few years one has seen/photographed essentially all of the interesting things in the night sky.
- So, the question becomes... Should I find something within astronomy that keeps me interested, or is it time to find another hobby to spend my time on?
- I would recommend going with the first option. Within that option, I can identify a few specific directions one can pursue:
 1. Buy better equipment and/or take much longer exposures.
 2. Travel to the southern hemisphere where there's a huge number of cool astro things that we can't see from up here in the north. Or, ...
 3. Simply revisit things you've already seen/imaged and hope to find that something has changed.
- The first two answers are the most commonly pursued directions. In this talk, I will elaborate on the third direction.

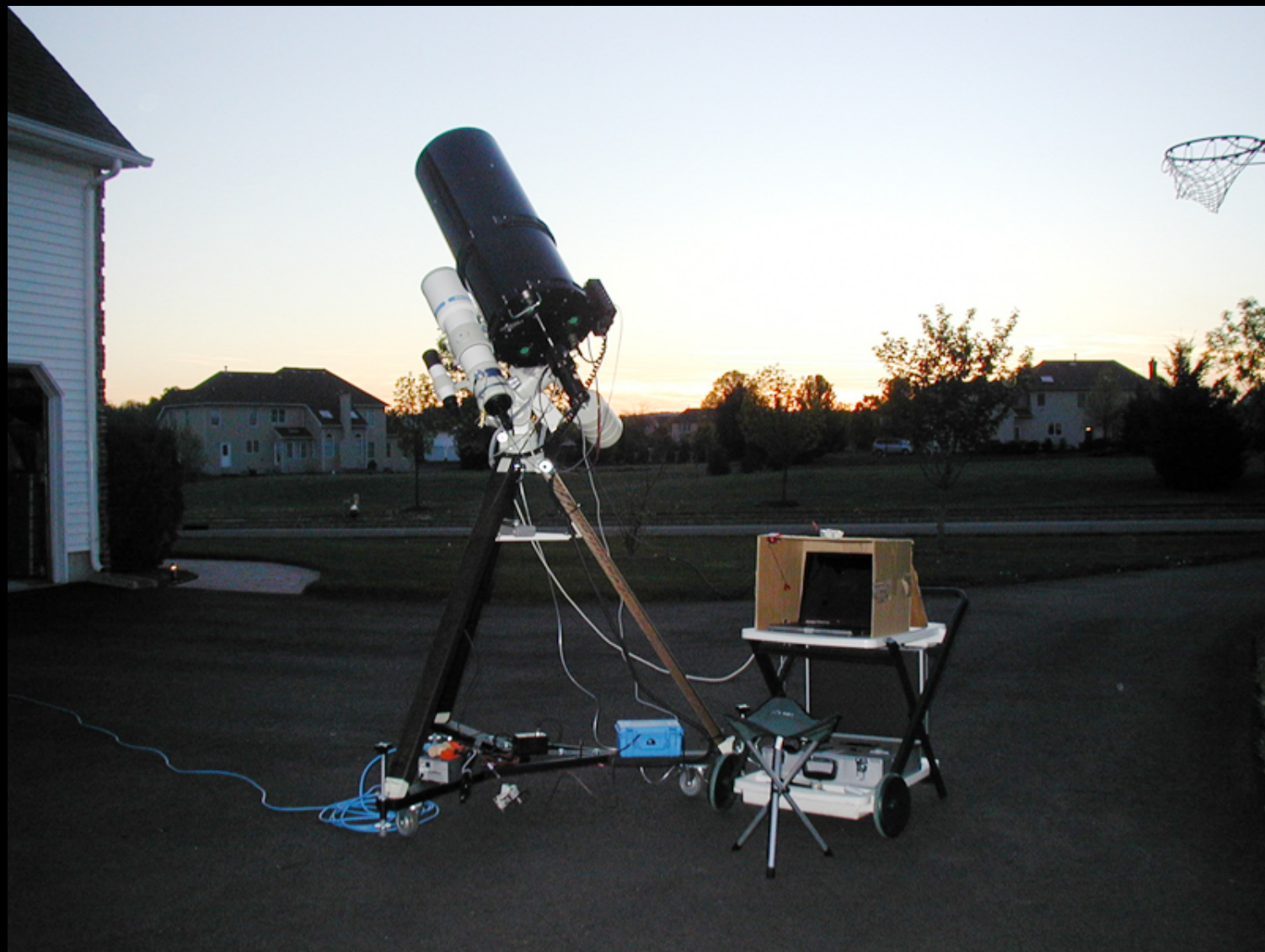
Equipment



Roll it outside.



Ready To Go...



Things Nearby



MiniMoon and SuperMoon



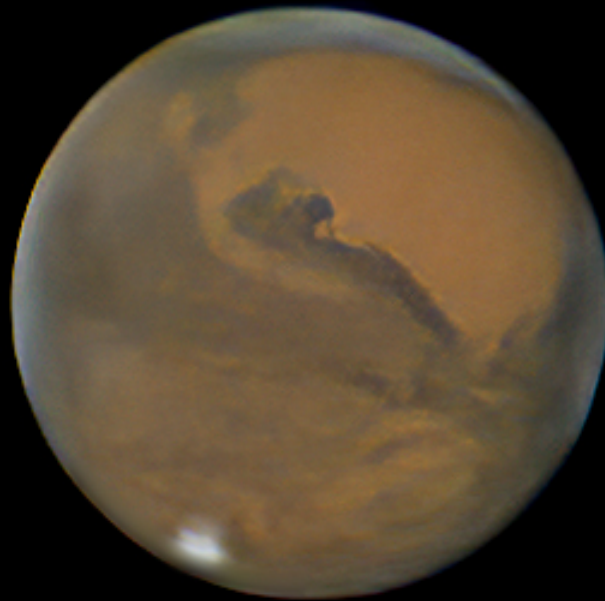
MINIMOON
Distance = 399,686 km
22:09 EST, Feb 3, 2015



SUPERMOON
Distance = 353,615 km
23:30 EDT, Aug 9, 2014

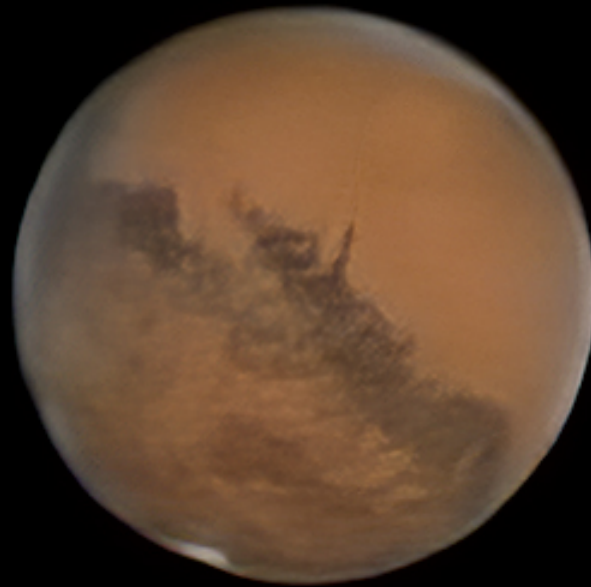
Mars

October 6, 2020



Mars

October 18, 2020



Supernovae







M61

May 13, 2020





Supernova Remnants – The Crab Nebula





Crab Nebula

There are two interesting things to observe in the animation:

1. The Crab Nebula's size varies. It's bigger in the 2019 image.
2. The bright star in the upper right part of the image seems to be moving.

Let's focus on the varying size of the nebula. It's expanding because this nebula is the remnant of a supernova explosion that took place in the year 1054 (almost one thousand years ago).

After a careful analysis, it appears that the nebula in 2019 is 1.288% larger than it was back in 2006.

Here's an animation in which the 2006 picture has been enlarged by a factor of 1.288% (the stars appear to move but the nebula doesn't vary)...





Crab Nebula

There were 4533 days between the two exposures. In years, that's $4533/365.25 = 12.41$.

If we denote the expansion factor by x and we assume a constant linear rate of expansion, then the formula for computing the date at which the supernova explosion took place is

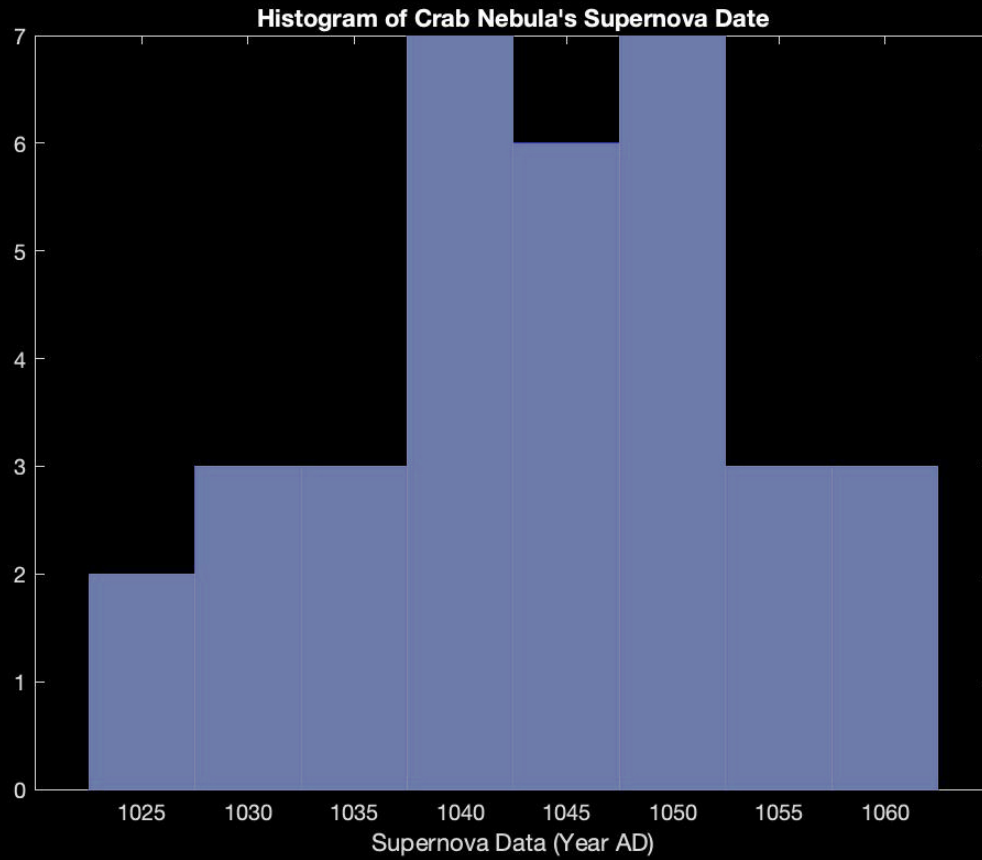
$$\text{date} = 2007 - \frac{12.41}{x}$$

Plugging in the value $x = 0.01288$, we get an estimate of the date for the supernova:

$$x = 0.01288 \implies \text{date} = 1043$$

I recomputed the estimate by subsampling the measurements 34 different ways. Here's the histogram showing the range of dates obtained:

Histogram of Dates



Future Supernovae? – Betelgeuse

Betelgeuse

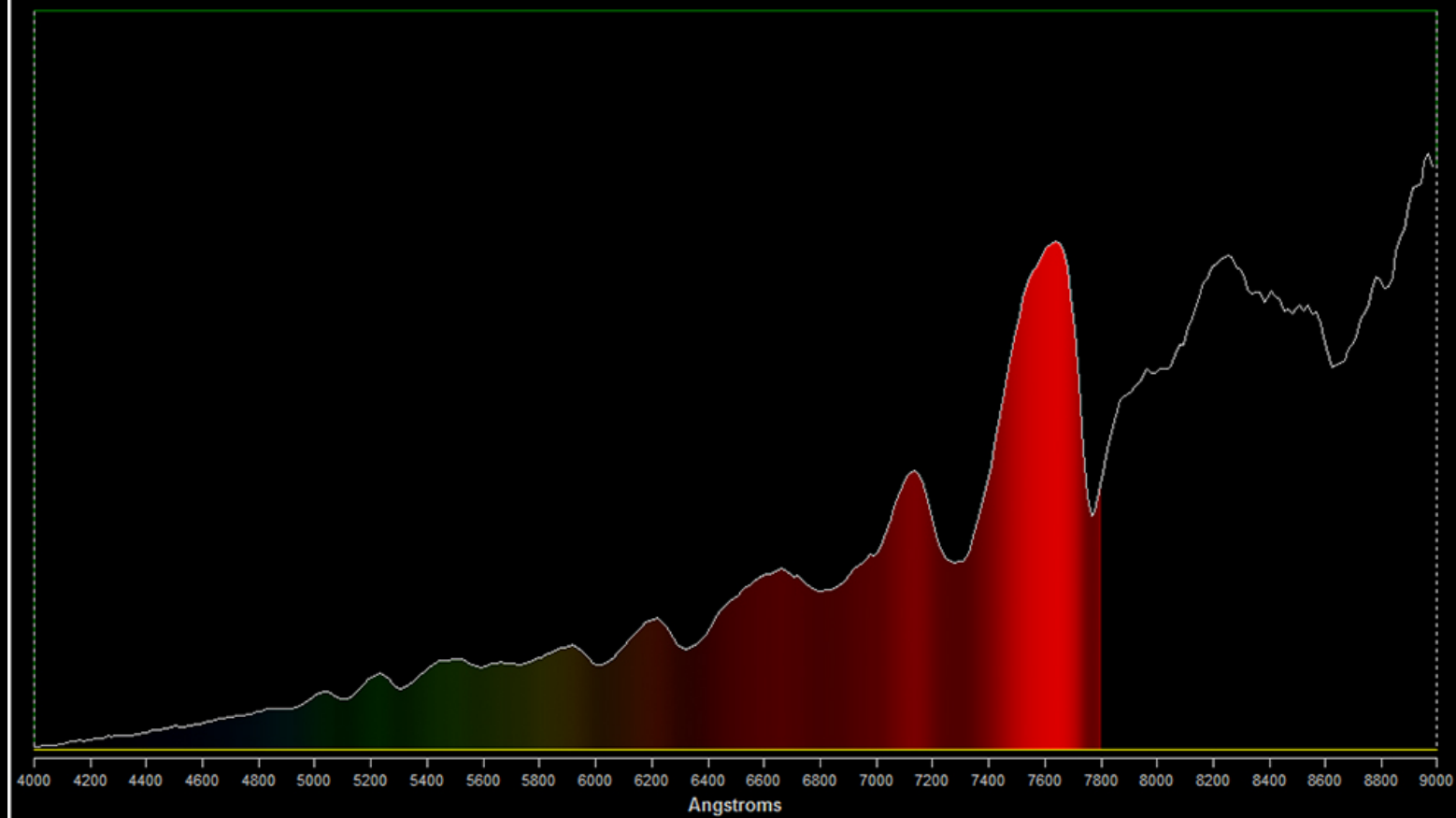


Betelgeuse

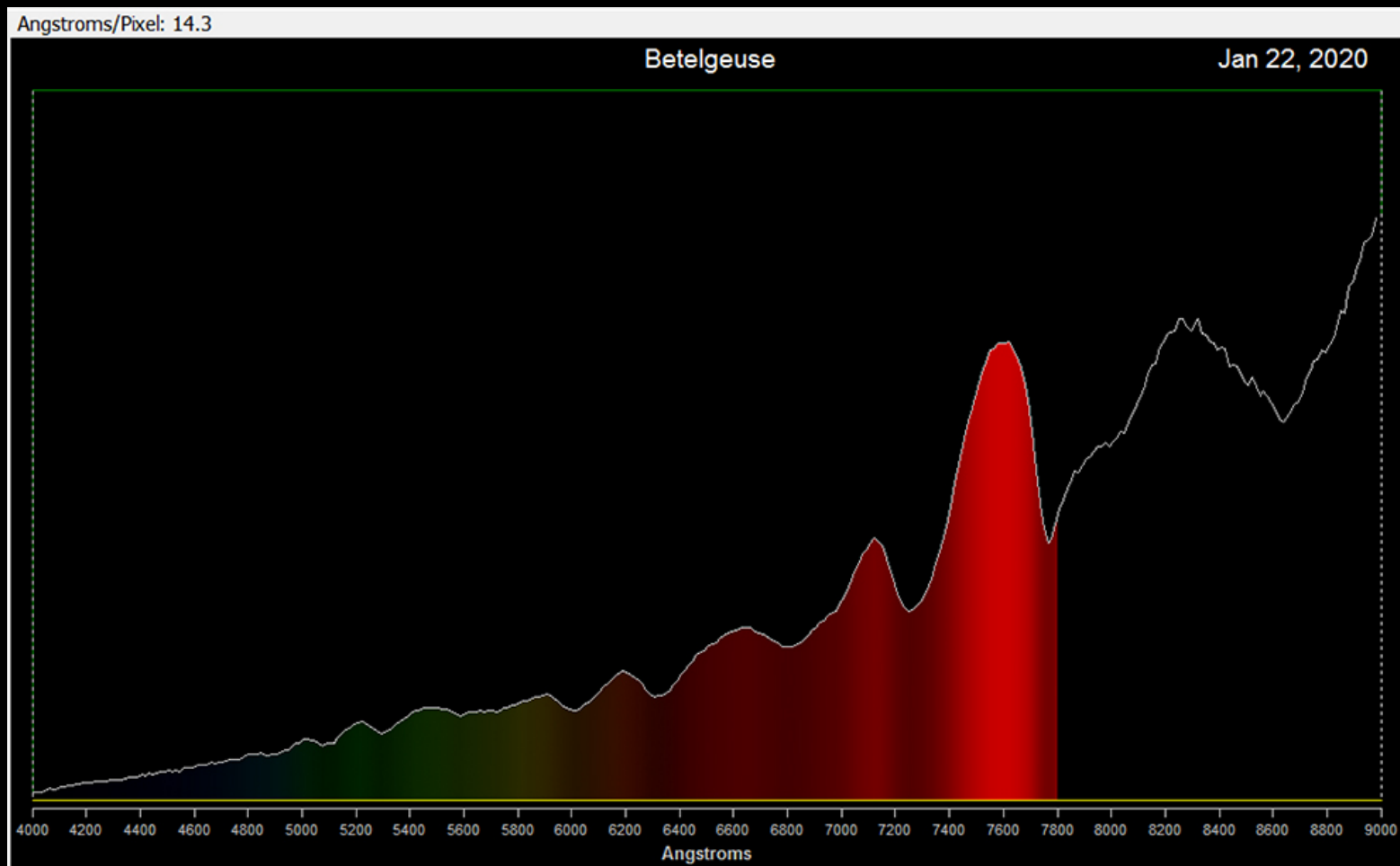
Angstroms/Pixel: 14.3

Betelgeuse

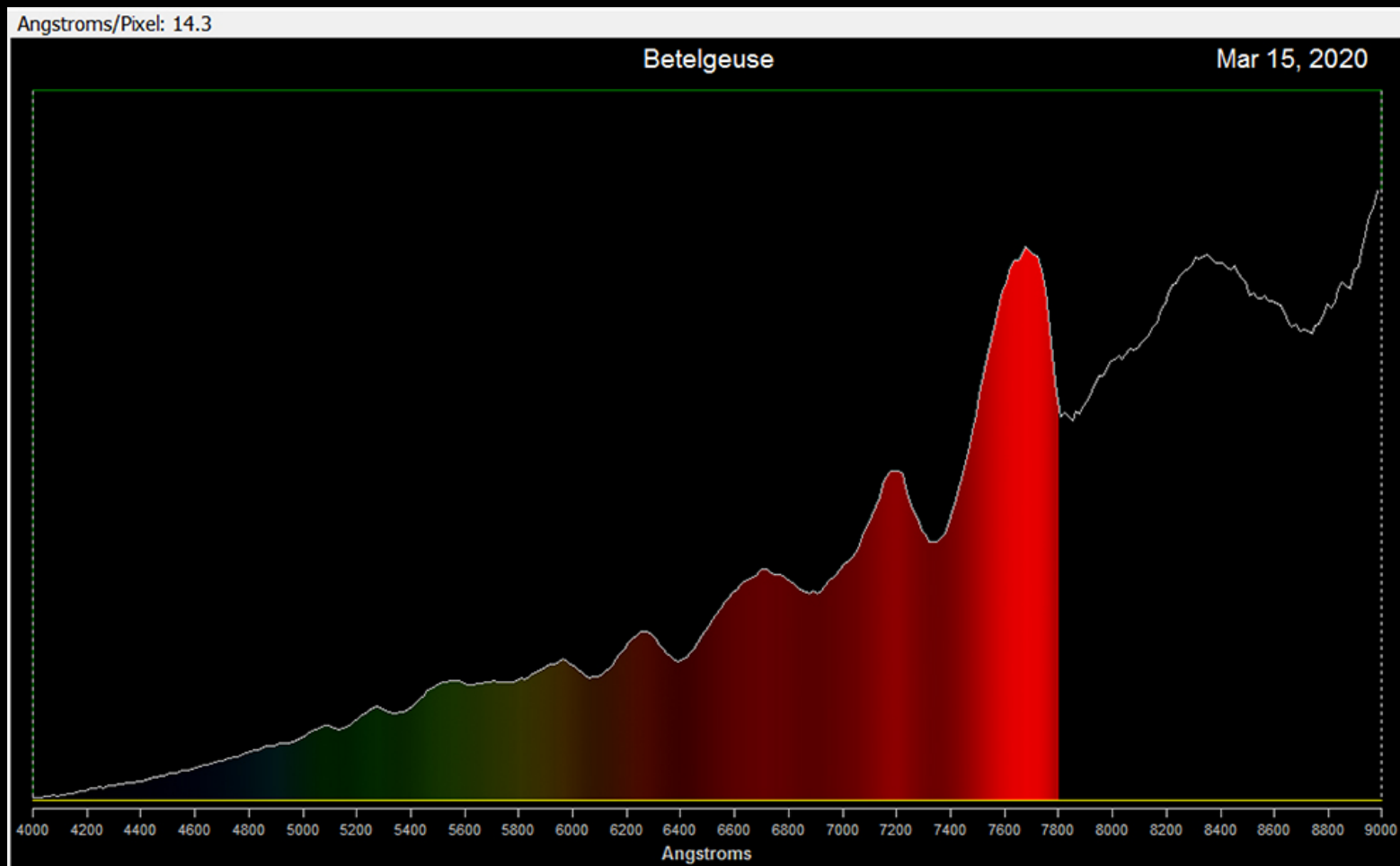
Jan 15, 2020



Betelgeuse



Betelgeuse



Proper Motion – Barnard's Star





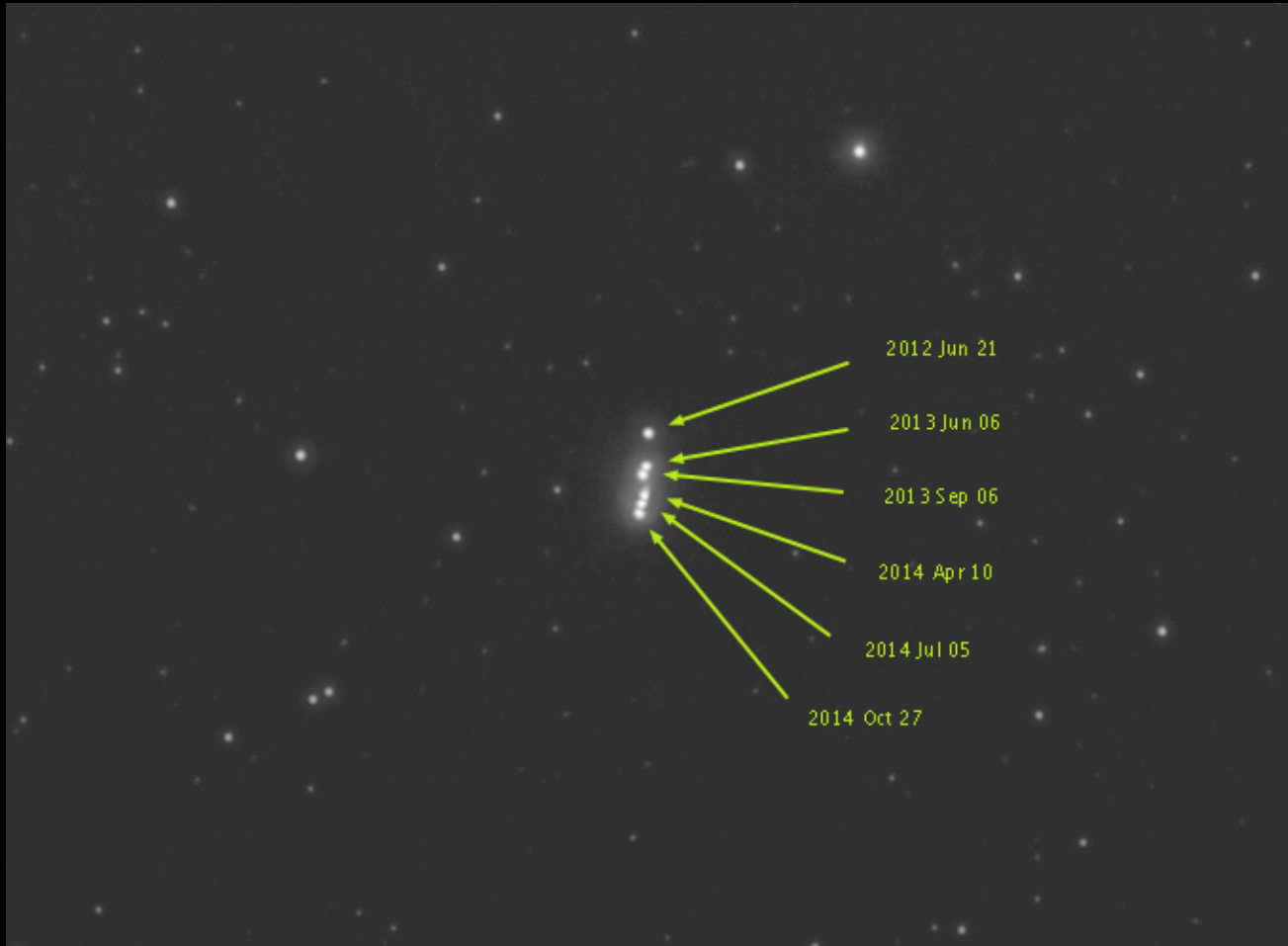




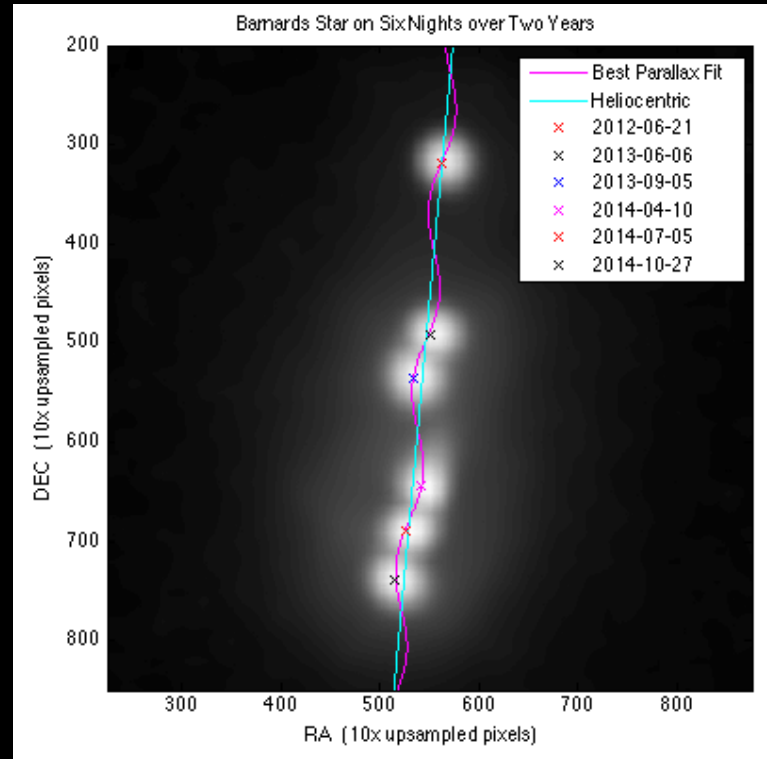




Barnard's Star Overlay



Barnard's Star Closeup



Parallax is 0.5478 arcsecs. \implies Distance is 5.97 ± 0.18 ly.
Proper motion is 10.5 arcsecs/yr.

Wikipedia: 5.96 ly
10.4 arcsecs/yr

M27 – The Dumbbell Nebula





Dumbbell Nebula

I uploaded the image from 2016 into <https://astrometry.net> to look up the exact coordinates of this picture.

I then used Cartes du Ciel (aka SkyCharts) to determine the precise RA and DEC of the variable object.

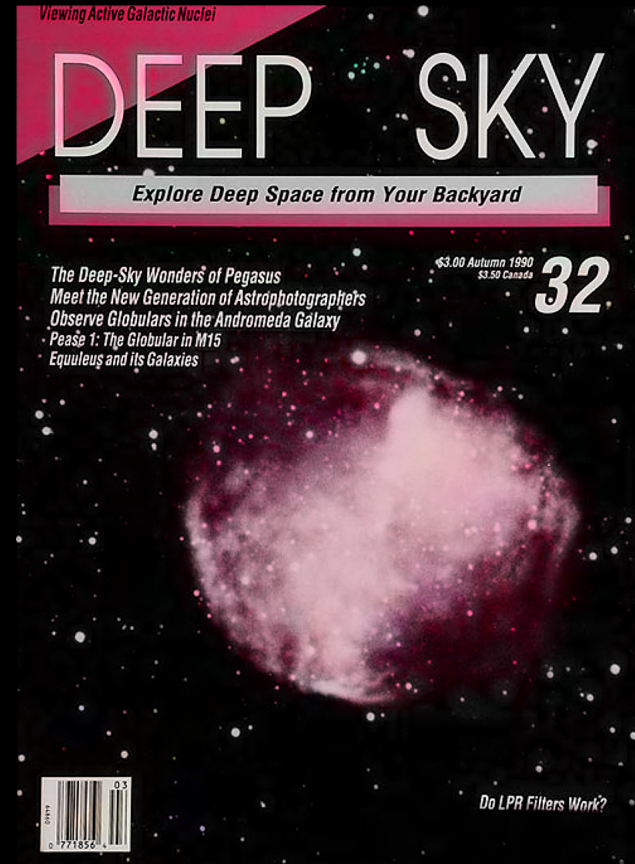
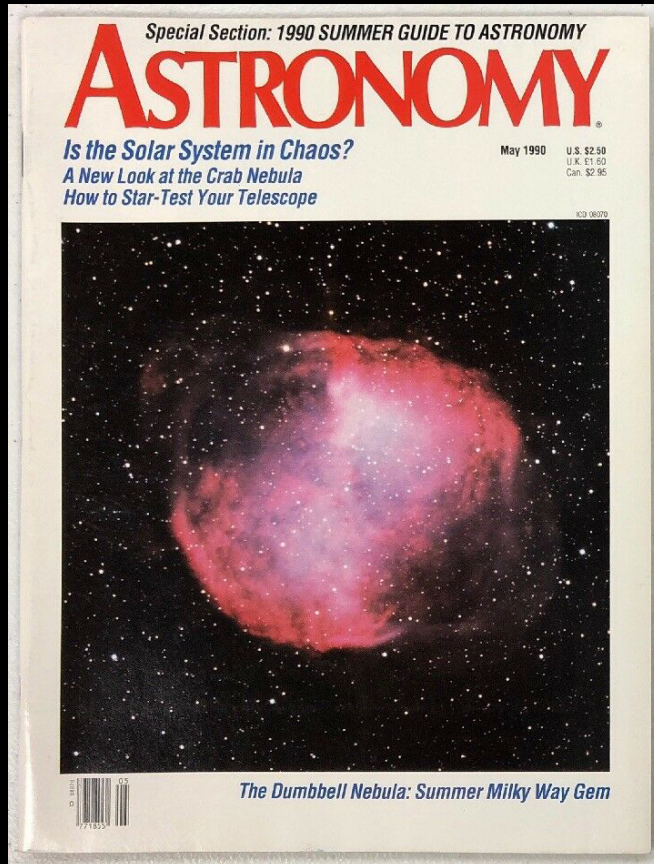
I uploaded the RA and DEC into the [Simbad](#) website and found that it is a *Mira variable* star.

It's *V571 Vul* in the *Variable Star* catalog and is also listed as a variable star in the Gaia DR2 catalog (number 1827257659609857072).

It was discovered to be a variable star only about 30 years ago...

Dumbbell Nebula

It was discovered by Leos Ondra in the spring of 1991 while looking at the covers of two astronomy magazines...



M13 – The Great Globular Cluster

M13 – The Great Globular Cluster

Date: 20:18-22:22 EDT, Sept. 4, 2018

Telescope: 10" Ritchey-Chretien at f/9

Mount: Takahashi NJP equatorial mount

Camera: Starlight Xpress Trius SX-694

Filters: L (6 min), R (8 min), G (6 min), and B (6 min)

Exposures: 20 seconds, unguided

Seeing: Best Frame: FWHM = 0.98 arcsec

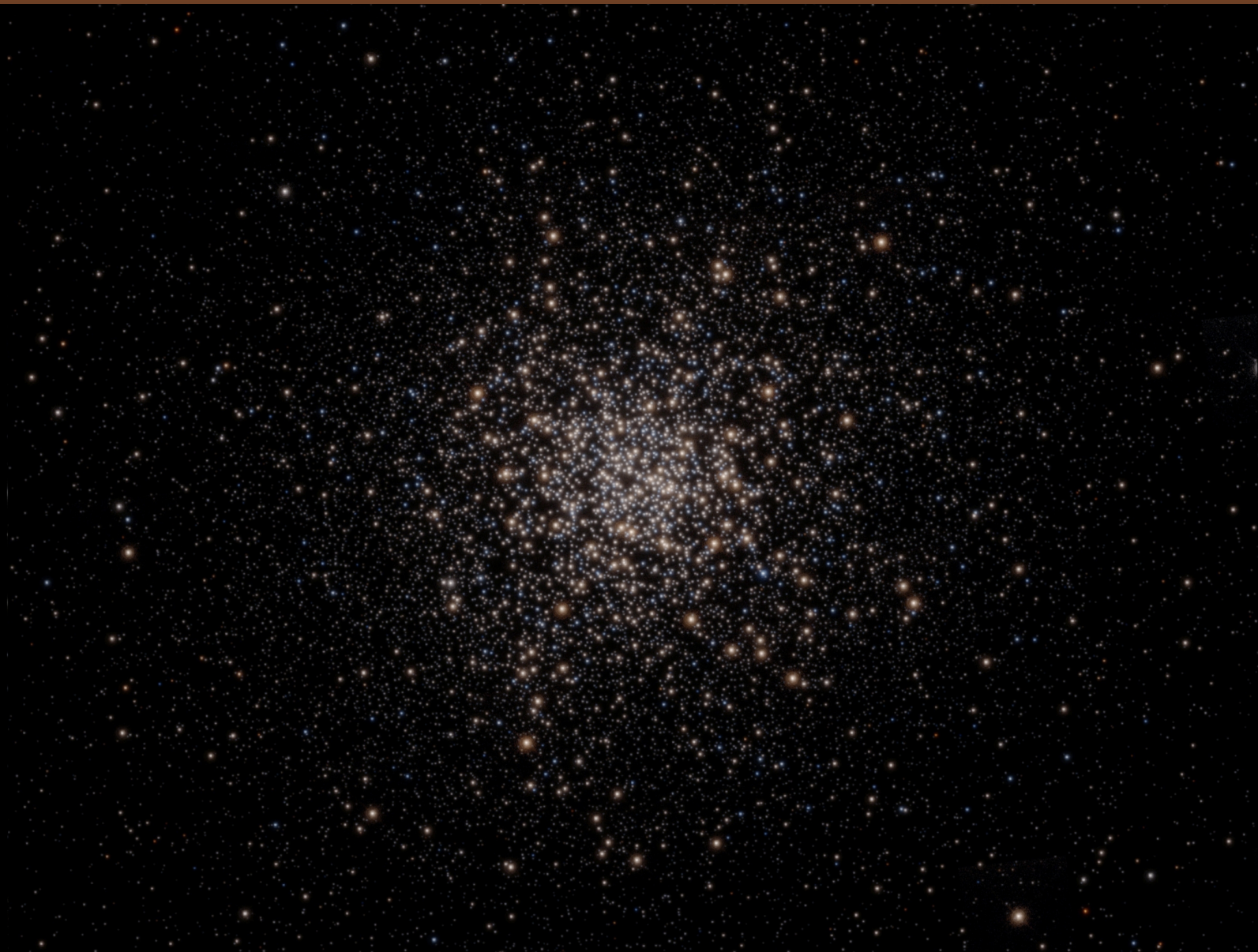
Stacked Image: FWHM = 1.18 arcsec

Processing: log stretch, unsharp mask

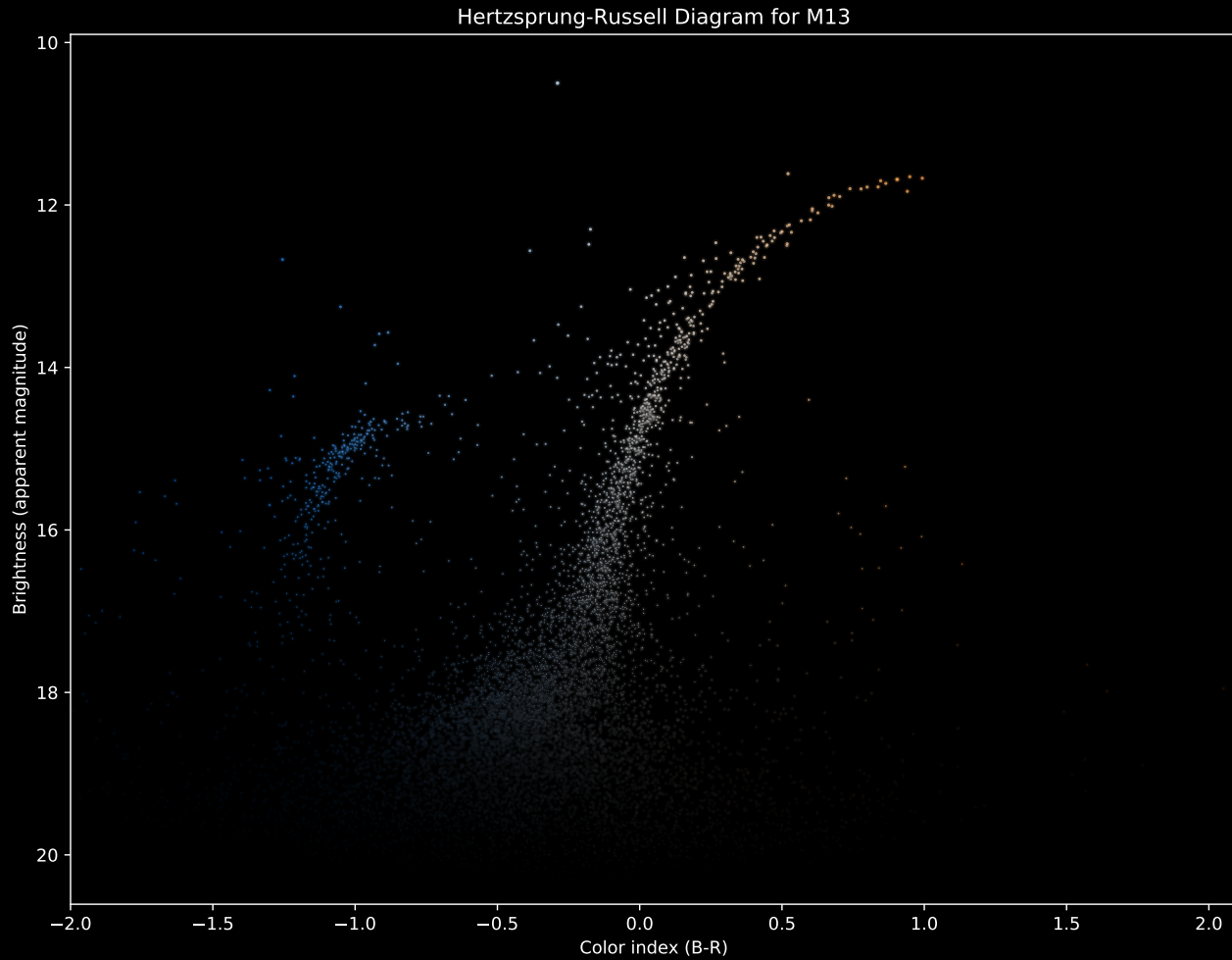
M13 – The Great Globular Cluster



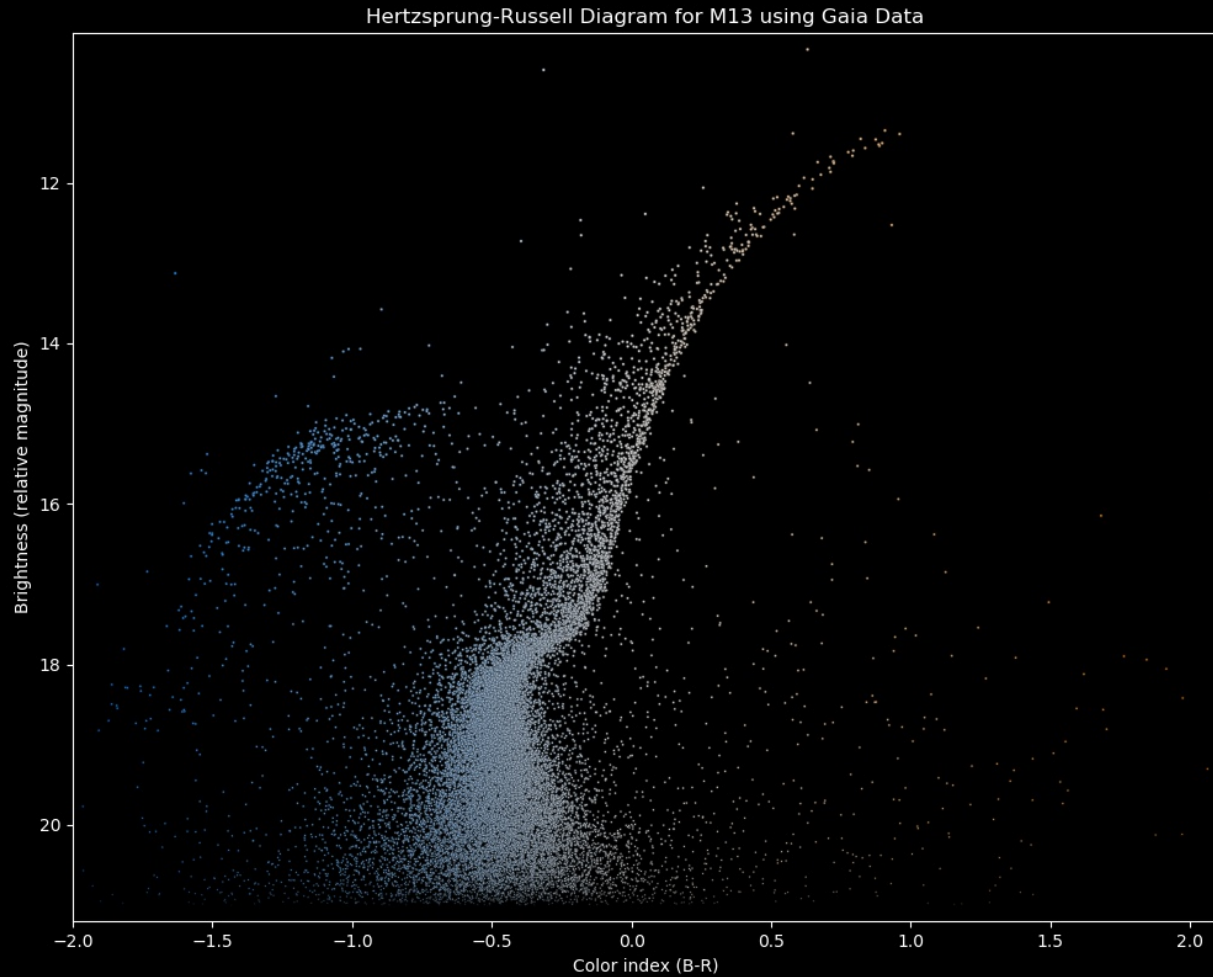
M13's Gaia Stars



HR Diagram Based On My Image



HR Diagram Using Gaia Data



M13's Variable Stars

M15 – Another Great Globular Cluster



M15 – Another Great Globular Cluster



M15's Variable Stars

M15's Variable Stars

M15's Variable Stars

Questions?