Betelgeuse occultation by 319 Leona (12 December 2023)

Photometric setup and protocol

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11th November 2023
Zoom meeting

One quartet dedicated to one chord

MM2

- We suggest that you stand on one of the 10 defined tracks A, B, C,… and J (according to IMCCE maps and in coordination with the host country) to build a chord.
- Observers are invited to team in a quartet on each track. Each observer is using a different filter (see following slides).
- On your track, you determine your Longitude Latitude Altitude location, the prediction of the middle of the event and the range of the acquisition period of at least 2 minutes and preferably 3 minutes. Therefore you start the event recording at least one minute before the predicted mid-event
- If necessary, you identify a fallback position on your track, according to cloud coverage forecasted the day before.
- The members of a quartet are not necessarily on the same location.

Diapositive 2

MM2 Miguel Montargès; 10/11/2023

Equipment setup requirements :
Optics

- High aperture telephoto lense : focal length from 50mm to 300 mm (the field of view may allow another bright star to be recorded as a reference).
- A telescope or a refractor : 60 to 100 mm in diameter. Larger diameters are also relevant for higher acquisition rates with a selective filter such as Halpha
- on a motorized equatorial or azimuthal mount
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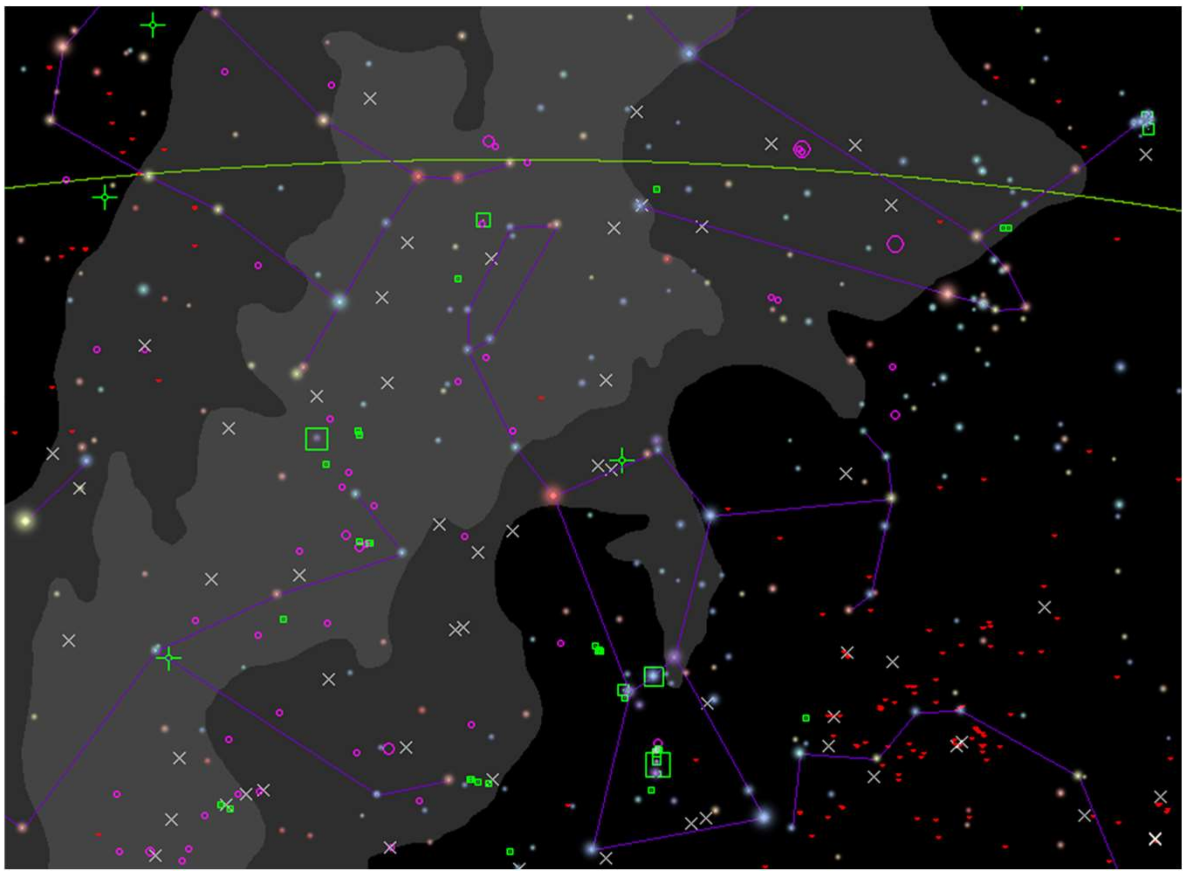


Alternate ref. stars : Orion Belt 10°, gamma Gem à 14°,Rigel à 19°, Aldebaran à 24°

Equipment setup requirements :
Filters

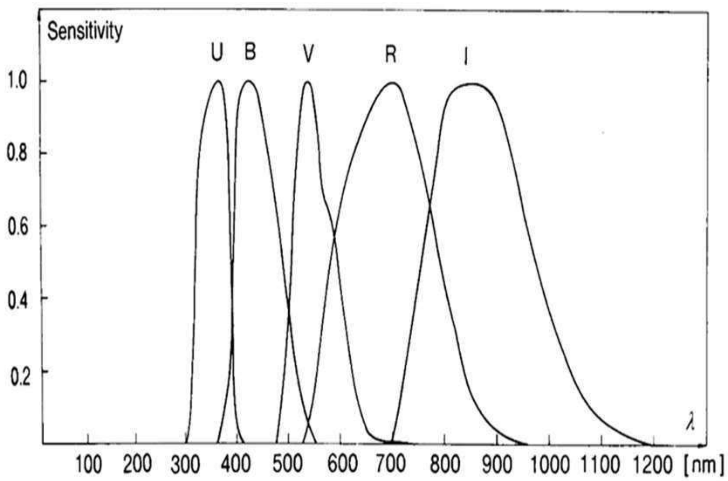
- An optical filter : in decreasing order of preference :

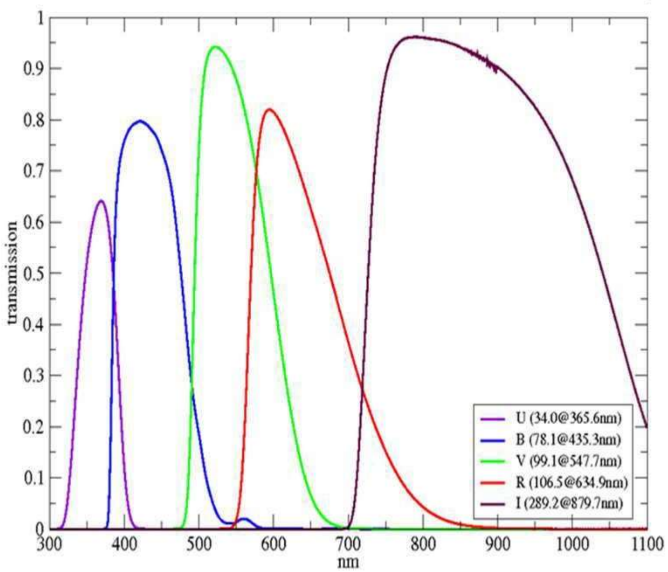
1. R (or I) as a reference,
2. then V (Visible) or G (Green),
3. then B,
4. then Halpha.

- These filters could be chosen in
  either Johnson Cousins set,
  or Bessel set,
  or Sloan set or PanSTARRS one's
  or trichrome set.
- Fill in your report the characteristics of each filter : supplier, λpic, λmin, λmax, bandwidth at mid-height).

- Therefore with the four filters, each observer team on one chord defines a string Quartet attached to a track ! 10 Quartets are distributed to the 10 tracks : A, B, C,… and J respectively

Johnson and Cousins filters U B V R I J K L M N…

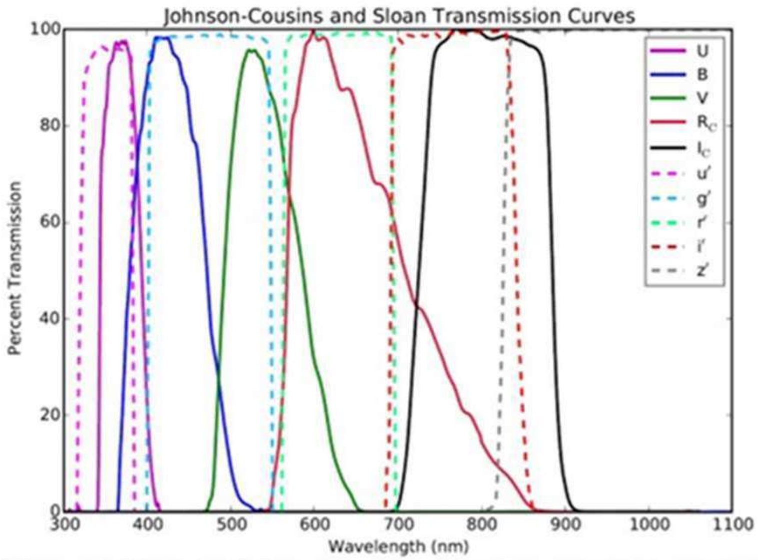


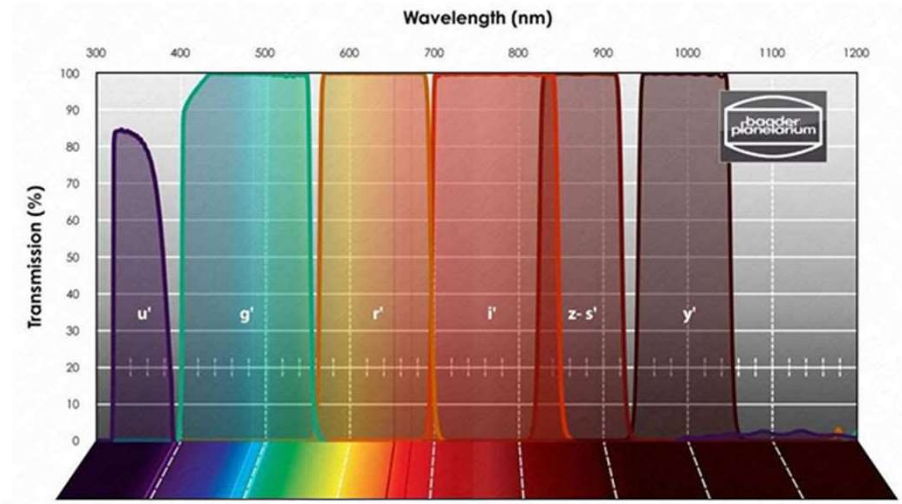


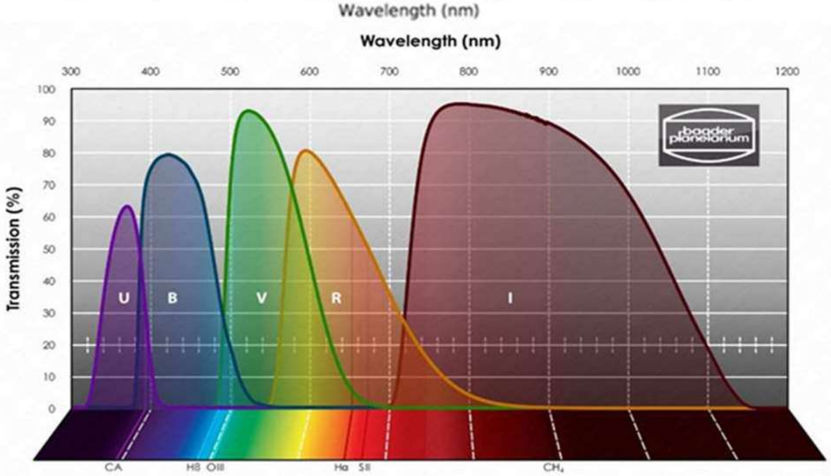
Filter Letter	Effective Wavelength Midpoint λ_{eff} For Standard Filte	Full Width Half Maximum (Bandwidth Δλ)	Variant(s)	Description
Ultraviolet				
U	365 nm	66 nm	u, u', u*	"U" stands for ultraviolet.
Visible				
B	445 nm	94 nm	b	"B" stands for blue.
V	551 nm	88 nm	v, v'	"V" stands for visual.
G			g, g'	"G" stands for green (visual).
R	658 nm	138 nm	r, r', R', R_c , R_e , R_j	"R" stands for red.
Near-Infrared				
I	806 nm	149 nm	i, i', I_c , I_e , I_j	"I" stands for infrared.
Z	m[3] 900 n		z, z'	

TM1

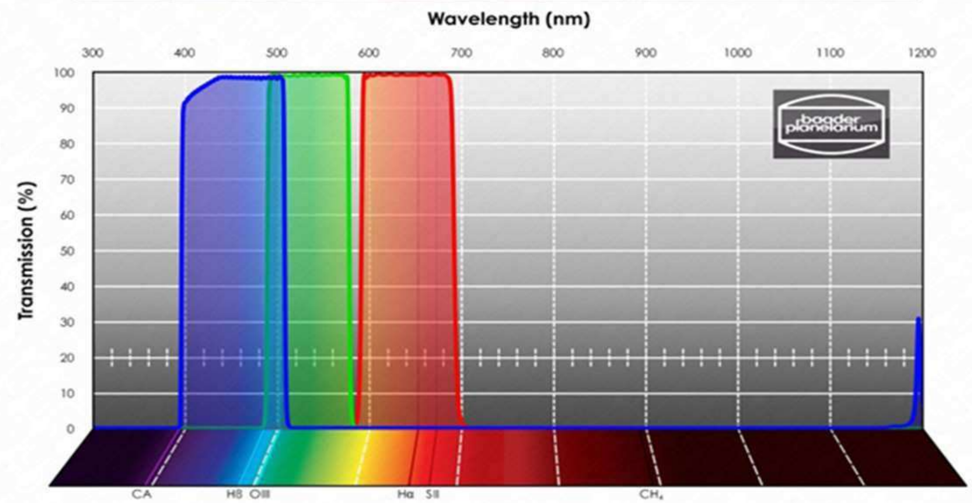
Filters: Bessel, Sloan SDSS (ugriz, u'g'r'i'z'), Pan STARRS (gp1, rp1, ip1, zp1, yp1), Trichrome RGB







BAADER UBVRI Bessel Photometric Filters



BAADER RGB CMOS Filter – *CMOS-optimized*

Diapositive 6

TM1 Thierry Midavaine; 10/11/2023

Equipment setup requirements :

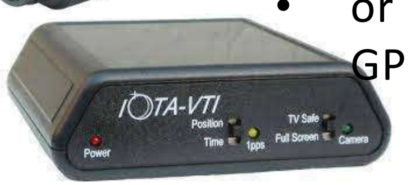
Camera and datation

Cameras :

- A digital camera monochrome (or panchromatic sensor) is preferred :
  - -Either a QHY174M embedding a GPS receiver allowing dating in the picture header
  - -Or a monochrome digital camera (uncooled or cooled) in identifying whether it is running in Global Shutter or Rolling Shutter mode (e.g. ZWO, Basler or IDS…).
  - -Or a digital colour camera (Bayer matrix or OSC), in specifying in addition the filters
- Or an analogic camera (Watec) with video inserter and a frame grabber.

Datation devices :

- A GPS-based dating system is preferred (QHY 174 GPS, TimeBox,…) giving the datum of each digital frame, or synchronising the camera with a log file recording.
- or a PPS GPS based inserter or time setting of the PC with a TimeBox or a Raspberry Pi4 + 1PPS GPS card – (Pierre le Cam contact) http://www.nocturno.fr/timeserver/timeserverstrate1.html
- or via NTP a time setting of the acquisition recorder or the PC (see next slide)
- or a RF broadcast sync such as DCF77, Allouis,… in assessing the datum latency
- The time inserter could also rely on optical or acoustic input to the camera
- or for analogic video camera (Watec,…) acquisition via a video inserter relying on GPS datum (IOTA VTI or TIM,…).



For digital video camera, a laptop computer with Sharpcap 4.0 installed (free o paid version) is preferred,

If no GPS, NTP with Meinberg is preferred

- Internet connection required with mobile phone (access point)
  - Meinberg:In this case, take the Meinberg software - https://www.meinbergglobal.com/english/sw/ntp.htm
  - With its monitoring software https://www.meinbergglobal.com/english/sw/ntp.htm#ntp_stable
  - Configuring NTP on a Paris Observatory address https://syrte.obspm.fr/spip/services/ref-temps/article/diffusion-de-l-heure-par-internet-ntp-network-time-protocol
  - Ideal with a fast, stable internet connection - Time updated every minute and log file to track corrections
- To be installed and tested before setting off on a mission

➢ Whatever your datation and time stamping solution is assess your datation accuracy. Breakdown your accy in a latency or timing bias, and, in a timing jitter. The target is to reach 1ms accuracy or to give a realistic figure.

➢ Check whether you are dating the start or the end of the effective exposure.

Energy budget

If you're on the move using a self-contained battery or a car battery, validate your autonomy (with regard to power consumption) by carrying out a test.

Remember your PC autonomy could be shorter if you feed the power to your camera through the USB link.

Remember : Switch on your setup not too early !

Remember the GPS may requires an init process of one hour when you switch on far from your previous location. In addition GPS receiver could be jam by electronics.

Tune accurately your camera driver :

This Betelgeuse event with its brightness and dynamic is unconventional for occultation observers.

Here is a process to find the best compromise on your setup

The USB link is usually the bottleneck of the setup. The max data rate is limited by the camera, the cable (or wireless link), the PC and SSD access.

A USB2 is limited to 480 Mega bit/s

A USB3 gen 1 is limited to 500 Mega Byte/s

A USB3 gen 2 is limited to 1 212 Mega Byte/s

- Find your maximum full frame rate in binning 1 at X fps.
- Are you are able to meet : 1000 fps ? 100fps ? 10fps is a minimum.

This limitation may comes from the above bottleneck or is native from your camera or your software.

Does a windowing or ROI (Region Of Interest) is able to improve this maximum rate ?

Fix your exposure time to 1/X fps : 100Hz gives you 10ms

QHY174MGPS bottleneck Tests

Sharpcap 4.1 (license version), Corei7 PC, SSD M2, 3mn long acquisition

- 16 bit or 2 Bytes /pixel output,

800 x 600, (10ms exp) Fits, 92fps effective = 88MB/s

800 x 600, (10ms exp) ADV, 98.98fps effective = 95MB/s

800 x 600, (20ms exp) ADV 49.74fps

640 x 480, (10ms exp) Fits 99 fps = 60.1MB/s

640 x 480, (10ms exp) ADV 98.98 fps effective = 60.1MB/s

- 8 bit or 1 Byte output

640x480 (10ms exp) ADV 99.42 fps

Then perform a first test on Betelgeuse :

- The gamma stick to 1 to keep a linear response
- Check the digital dynamic of the camera. Either you are able to fix it to 16, 12 or 10bits, or this is a consequence of the gain you will tune after. Choose the maximum digital dynamic range attached to your camera. Keep in mind the digital signal will be delivered in 2 Bytes (16 bit).
- Then target Betelgeuse with your lense (full aperture) or your telescope equipped with your filter.
- Avoid the saturation of Betelgeuse at all cost (even with the scintillation effect) and you need high signal dynamic range to meet the forecasted deepest magnitude. From the lowest possible gain increase your gain to keep the signal close to ½ the saturation level.
- Keep in mind Betelgeuse is rising in elevation during the hours before the event in Europe.
- If you feel to be closed to saturation, apply a slight defocus. You keep the signal in avoiding any saturation risk.
- Check your offset to put the sky background signal and read noise just above 00
- Preliminary tests to be carried out with Betelgeuse at a height equivalent to the night of the occultation (between 50° and 60° high).
- Acquire 2min or 3min long recordings
- **Test that you safely detect a magnitude 5, 6, 7,… star** (which simulates the Betelgeuse brightness at mid event) with the defined setup in using the same setting.

Diapositive 12

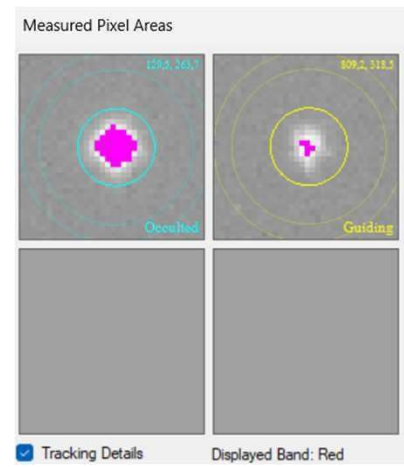
MM10 La dernière phrase n’est pas claire pour moi
Miguel Montargès; 10/11/2023

TM2 Le but est de limiter le gain
Thierry Midavaine; 10/11/2023

MM13 En caractère gras : Test that you safely detect a magnitude 5-7 star with **the same setup** (which simulates the brightness of Betelgeuse during the event)
Miguel Montargès; 10/11/2023

Pre-test and configuration validation protocol with your image processing software (Tangra, …)

- Target Betelgeuse with the chosen device (filter, telescope, camera, dating system, and the defined setting)
- Test the exposure time with a small series of images (record in FITS or SER "video") - set to 16bits and low gain, staying around 50% of saturation.
- Analyse these test series with Tangra V3.7 and check that the images do not show Tangra saturation (purple dots on the star).
- **Do a test with the same parameters as for Betelgeuse, on a star of magnitude 6 to 7 to see if it is detectable and measurable (what is the S/N?).**
- Perform a longer series to check that there are no "dropped frames" during a long acquisition (3 minutes).
- Record all the parameters (gain, offset, exposure time, effective rate).
- Do you have any other stars in the field ?



On-site preparation

- After your chord has been allocated by the organising team, find the observation site (max 100 m from the theoretical rope).

  first of all with the help of google maps then check on the spot

- Once the site has been validated, check that there are no obstructions to setting up your equipment or to get Betelgeuse in advance (everything happens on the South-East before the Meridian transit for Europe).

- Make a note of the actual coordinates of the proposed site and pass them on to the coordination team

Dress rehearsal D-1

- Going out into the field to get ready to pull out all the stops
- You need to put yourself in the same conditions as on the day of the occultation to test the whole system (battery, PC, telescope, camera).
- Start up the GPS. Starting up the GPS from a new site may require at least one hour of acquisition time to bring it up to speed on the position.
- Repeat an acquisition test
- Prepare a brief report for debriefing with the organising team
- Test your Slack link

- Commentary: Check your effective cloud coverage and any attenuation effects. Cirrus coverage may decrease your signal. Keep your setting to be sure you never saturate even if Betelgeuse appears in a cloud hole.

D-Day

- Check weather forecast in the 12 hours preceding the event to confirm your site or choose a back-up or alternative site.
- Go to the site with enough lead time to assemble everything and set up the telescope (validate your residual drift), but not too much in order to save power for the Laptop and telescope depending on your autonomy.
- To record the occultation, make a 3-minute recording centred on MM17 the expected time of the event (90s before and 90s after - to probe Leona's environment).
- Make another recording before or after to record the scintillation and seeing conditions.
- Remind : FITS or SER video (ADV for a QHY174MGPS) - 16 Bits
- Preferred acquisition software : SHARPCAP 4.0 or 4.1
- Record all acquisition parameters and position in the report.

- **You have done it ! Champagne ! This is an Achievement !**
- **Record a copy of your file.**

Diapositive 16

MM17 PC → laptop
Miguel Montargès; 10/11/2023