Astrophotography Processing Techniques

MAS Astro Imaging Group
9 May 2026

Topics

1. Dithering
2. Image Stacking
3. Gradient Reduction
4. Image Stretching
5. The Curves Tool
6. Using Masks

1 Dithering

Breaking up fixed-pattern noise between frames

Dithering

- **What is it?**
- **Why do it?**
- **How much and how often?**

Dithering is

MOVING THE SCOPE a small distance in a random direction between frames

But won't that blur the image?

Stacking software aligns the stars in the image.

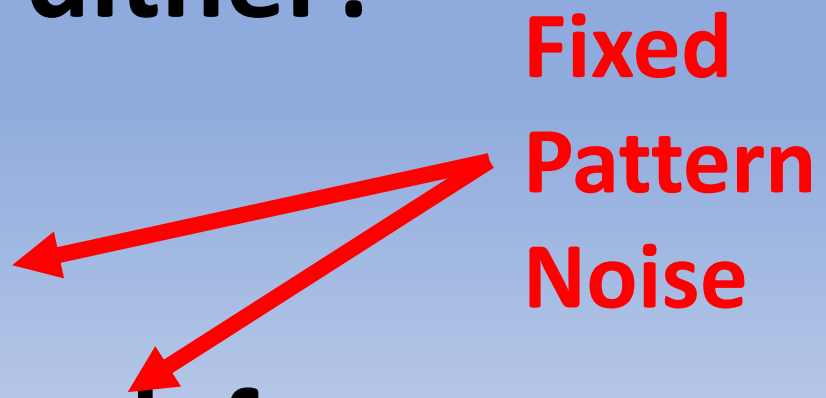
Hmmm, stacking re-aligns the stars you made not align …
so why bother

What does dithering look like?

Video from youtube channel: Kai Seestar

Why dither?

- Hot pixels
- Other sensor defects
- Walking noise



Why dither?

Hot pixels are always turned on.

They are in ALL sensors

Why dither?

Defective (dead) pixels that are always OFF

Dark frames will help reduce many problems with pixel defects.

Why dither?

Walking noise is a problem of pixel defects made worst by stacking

Why dither?

Walking noise is due to

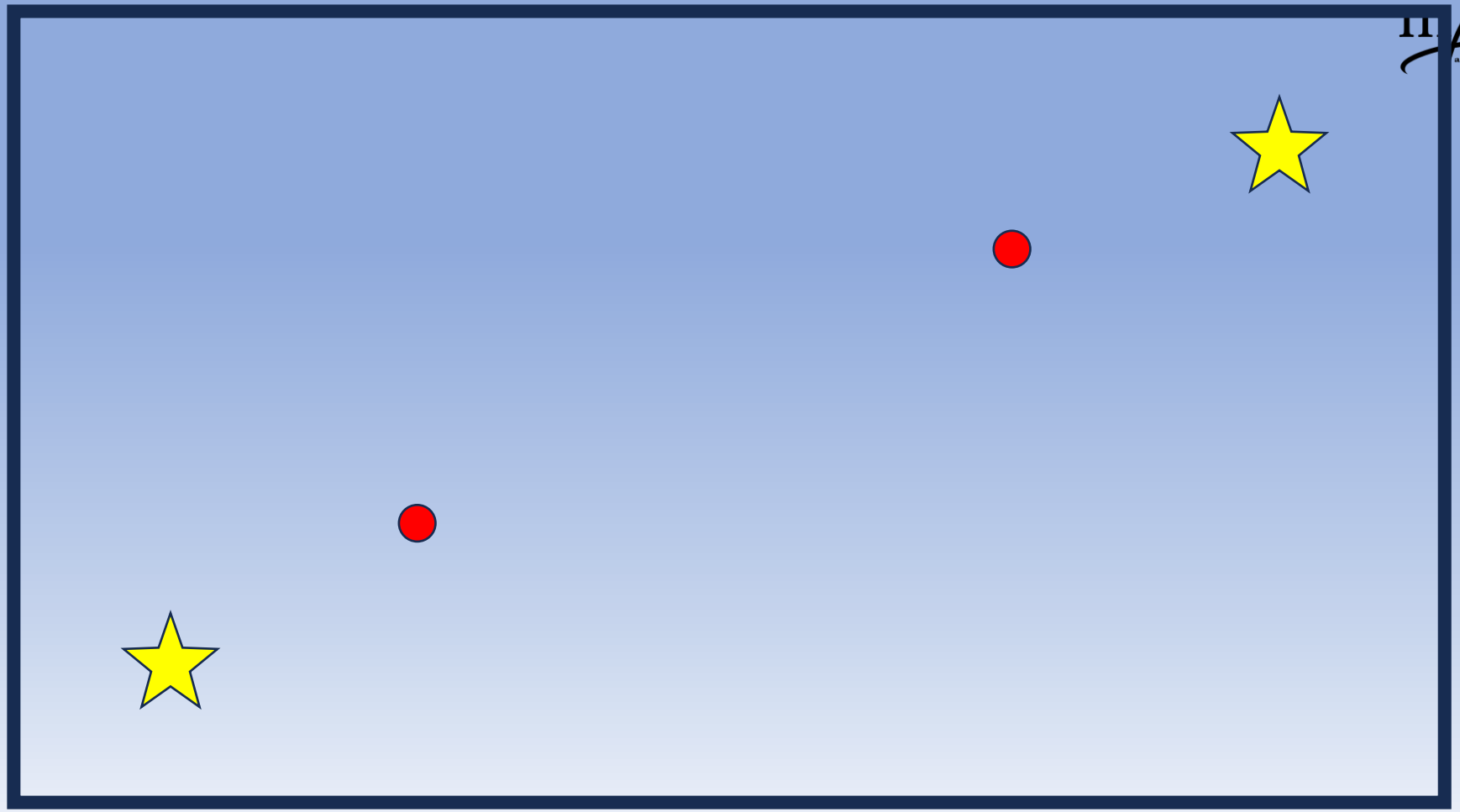
- **pixel defects**
- **slight misalignment to celestial pole**
- **flexure in image/guide train**

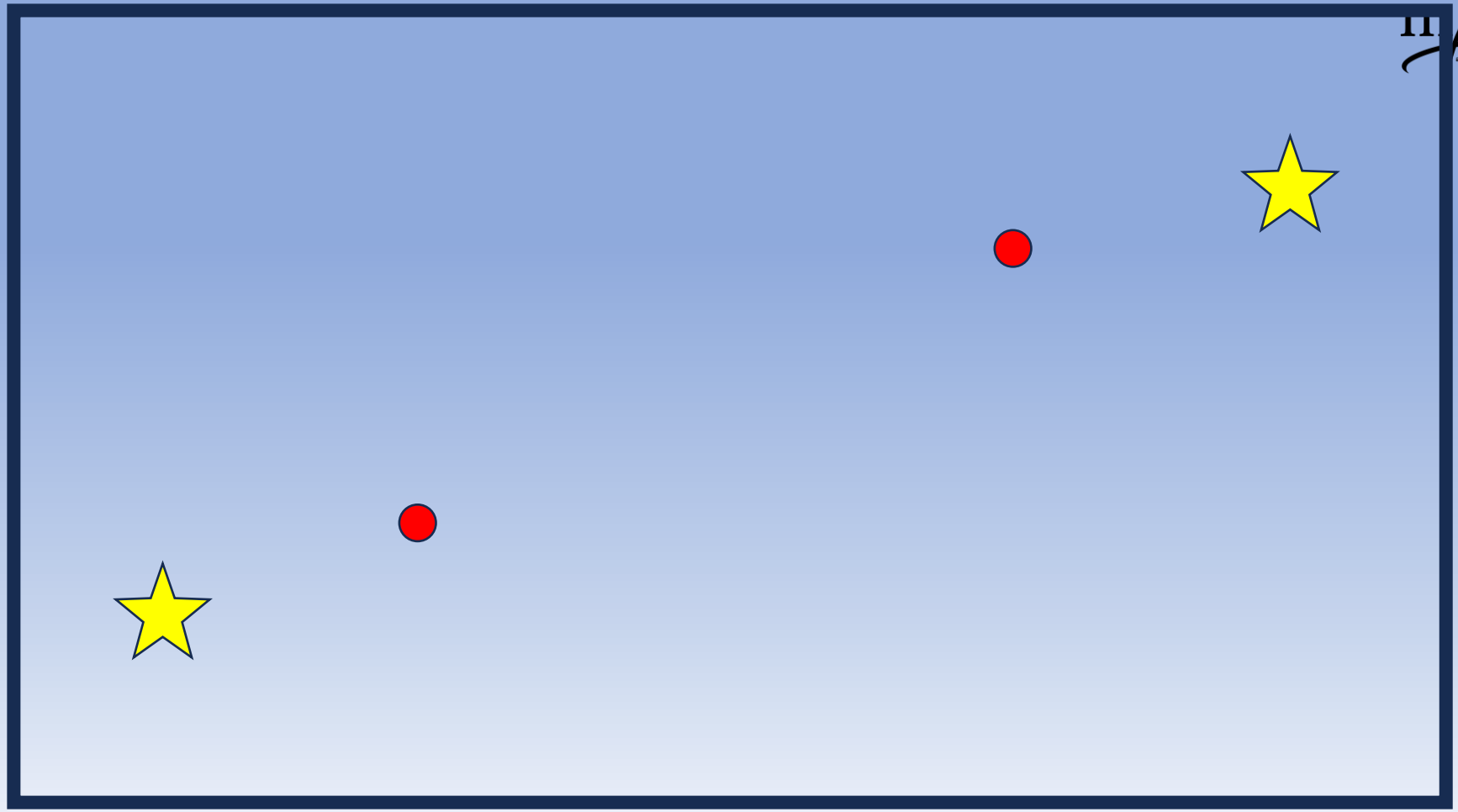
Pixel defects in the sensor are ALWAYS in the same place.

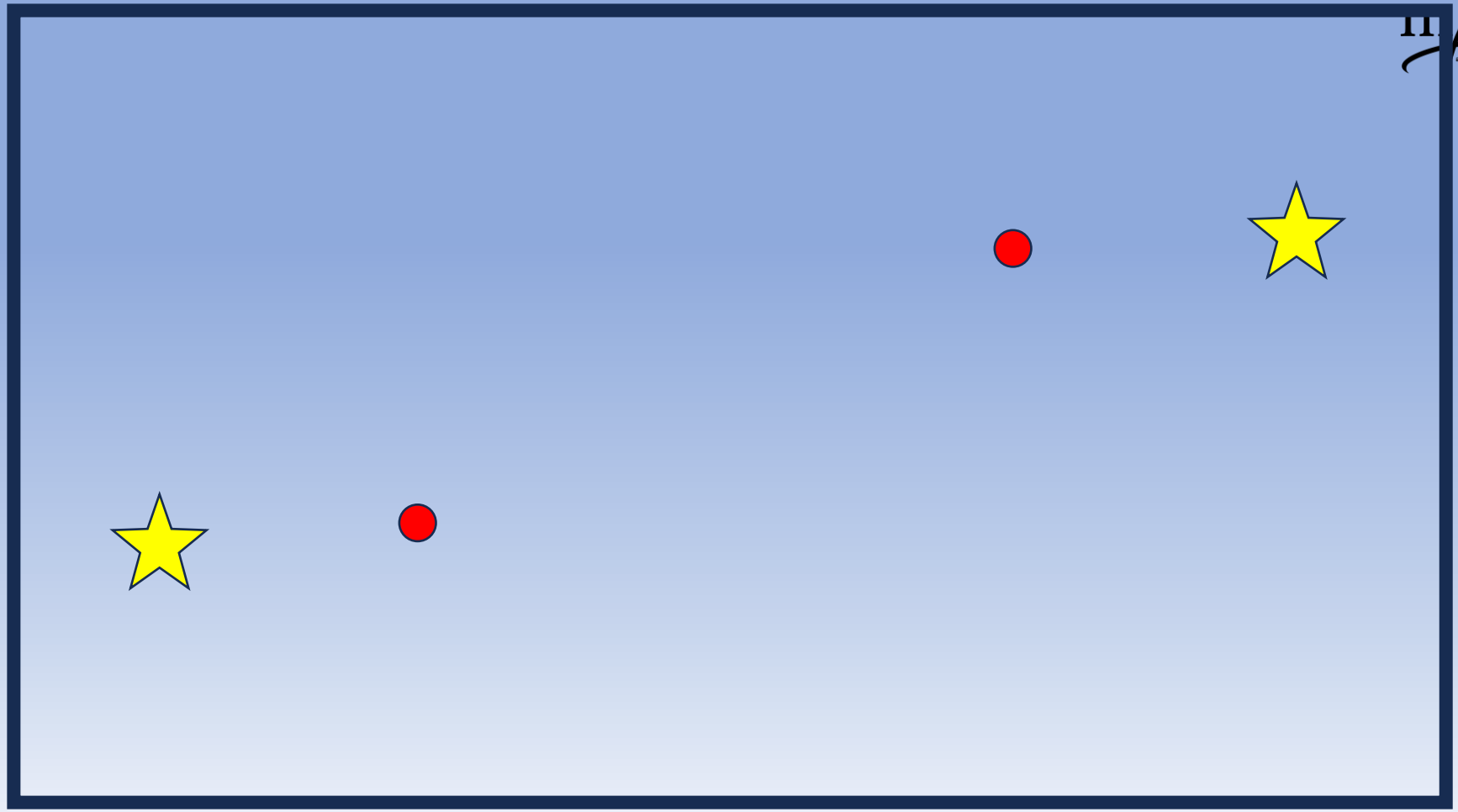
With PERFECT polar alignment and PERFECT gear the images of stars are always in the same place on the sensor..

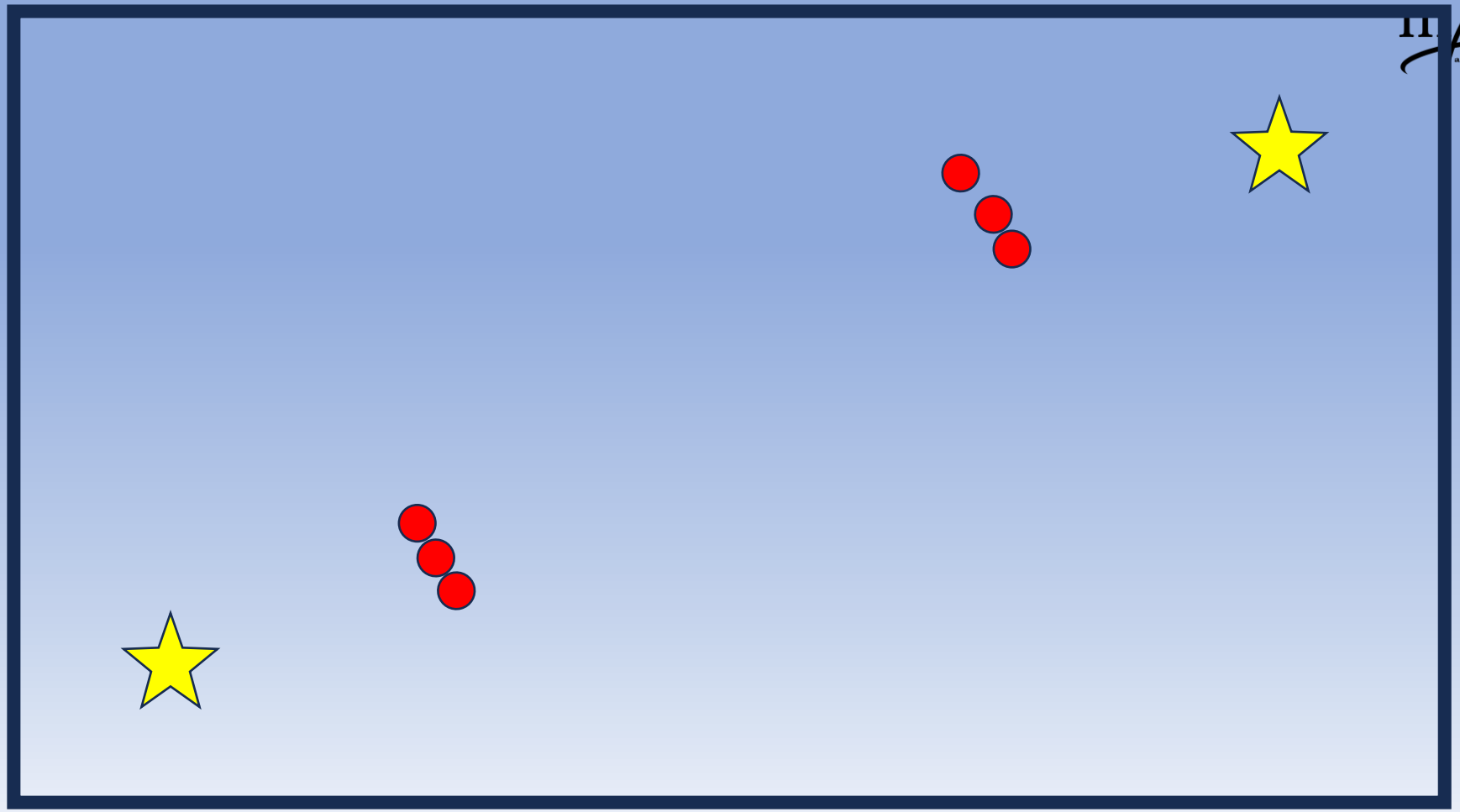
With NORMAL polar alignment and REAL gear the images are taken and stacked, the stars are aligned, but the FRAME changes.

When stars are stacked, the noise APPEARS to move across the screen leaving the streaks that are walking noise.









Why dither?

Dithering increases signal to noise ratio SNR

How far to dither?

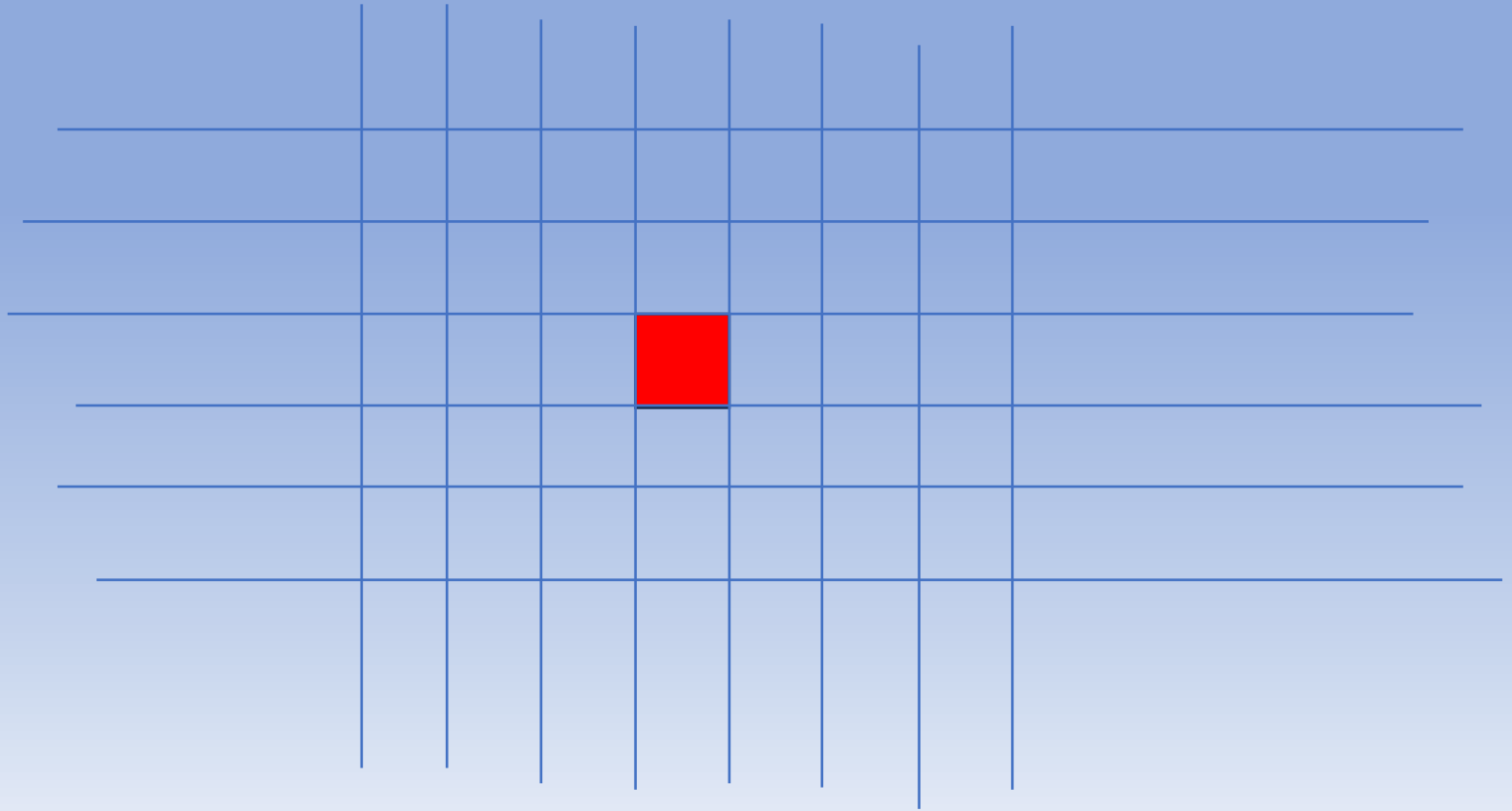
The simple answer is

1, 2, 3, 5, 7, 10, 15, 20, 30 pixels

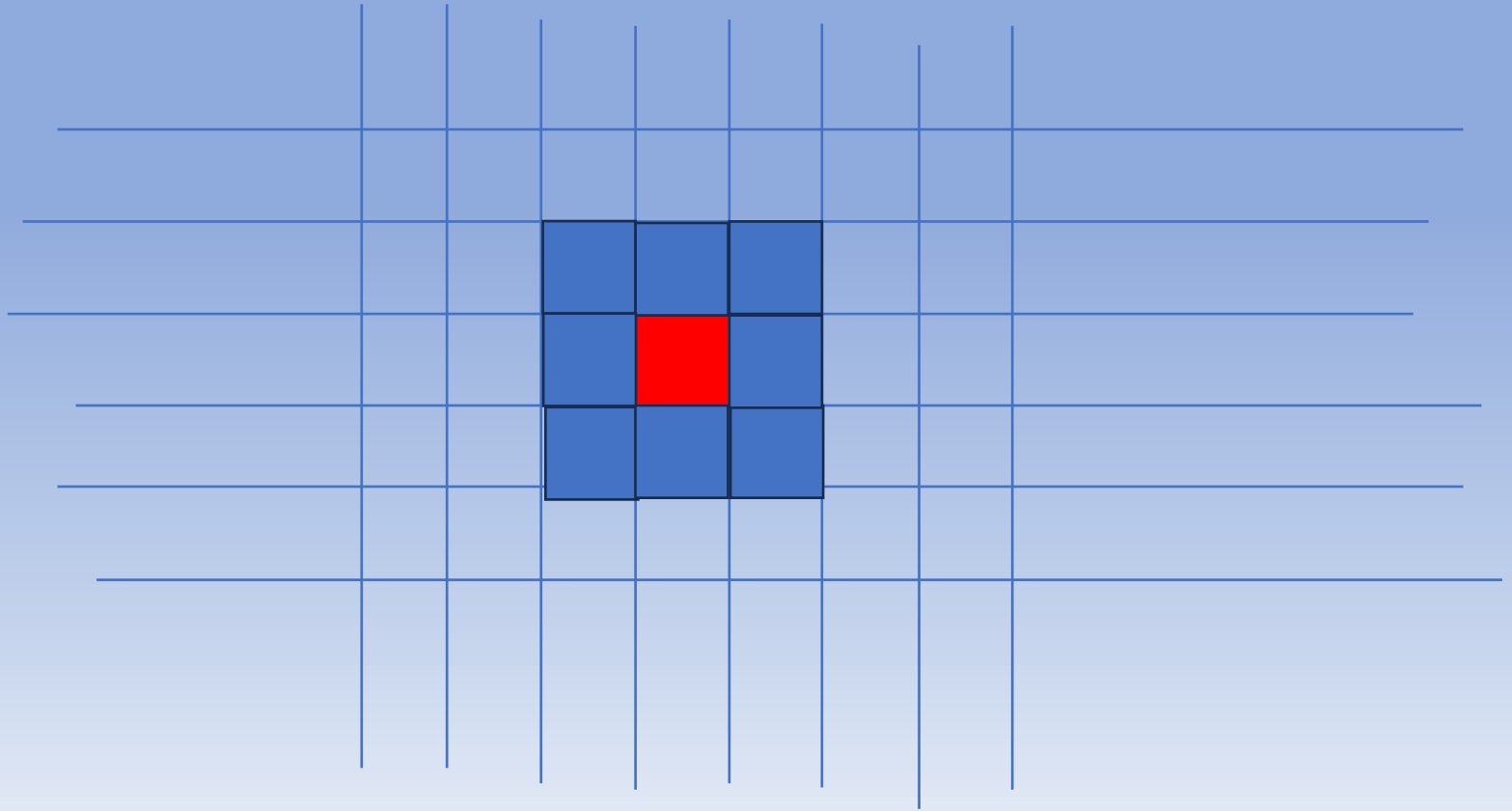
????????????

WTF my head hurts

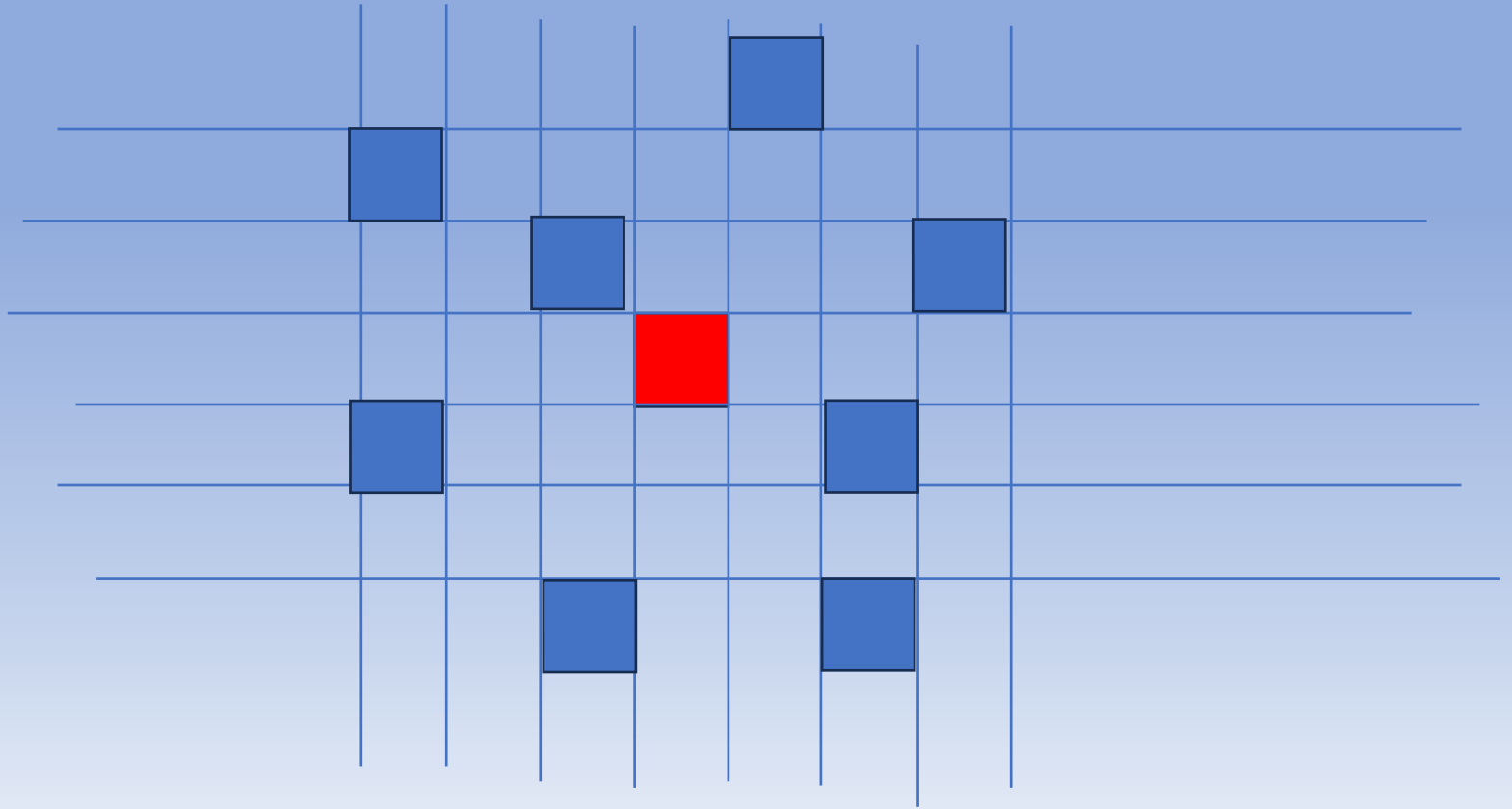
ONE problem pixel



Dither ONE pixel



Dither THREE pixels



How far to dither?

Most advice is:

- **Dither 10 pixels on the IMAGING camera**

How far to dither?

If using a smart scope:

- **It is turned on to some pre-set value**
- **Just use it**

How far to dither?

If using a separate guide scope:

- **The dithering you set is for the guide scope not the imaging scope**

How far to dither?

You need to calculate how far to dither the guide scope to get 10 pixels on the imaging scope

??????????

How far to dither?

Calculate the scope resolution in arc seconds per pixel

$$\frac{\text{Camera pixel size (microns)}}{\text{Scope focal length (mm)}} \times 205.265$$

How far to dither? An example

Imaging Scope: 360 mm focal length

Camera: 3.76 microns

$$\frac{3.76 \times 205}{360} = 2.15 \text{ arc seconds / pixel}$$

So 10 pixels = 21.5 arc seconds

The imaging scope needs to move up to 21.5 arc seconds in a random direction

How far to dither? An example

Guide scope: 250 mm focal length

Guide camera 3.75 microns

$$\frac{3.75 \times 205}{250} = 3.09 \text{ arc seconds / pixel}$$

BUT the guide scope needs to move the imaging scope 21.5 arc seconds.

How far to dither? An example

Guide scope: 250 mm focal length

Guide camera 3.75 microns

$$\frac{3.75 \times 205}{250} = 3.09 \text{ arc seconds / pixel}$$

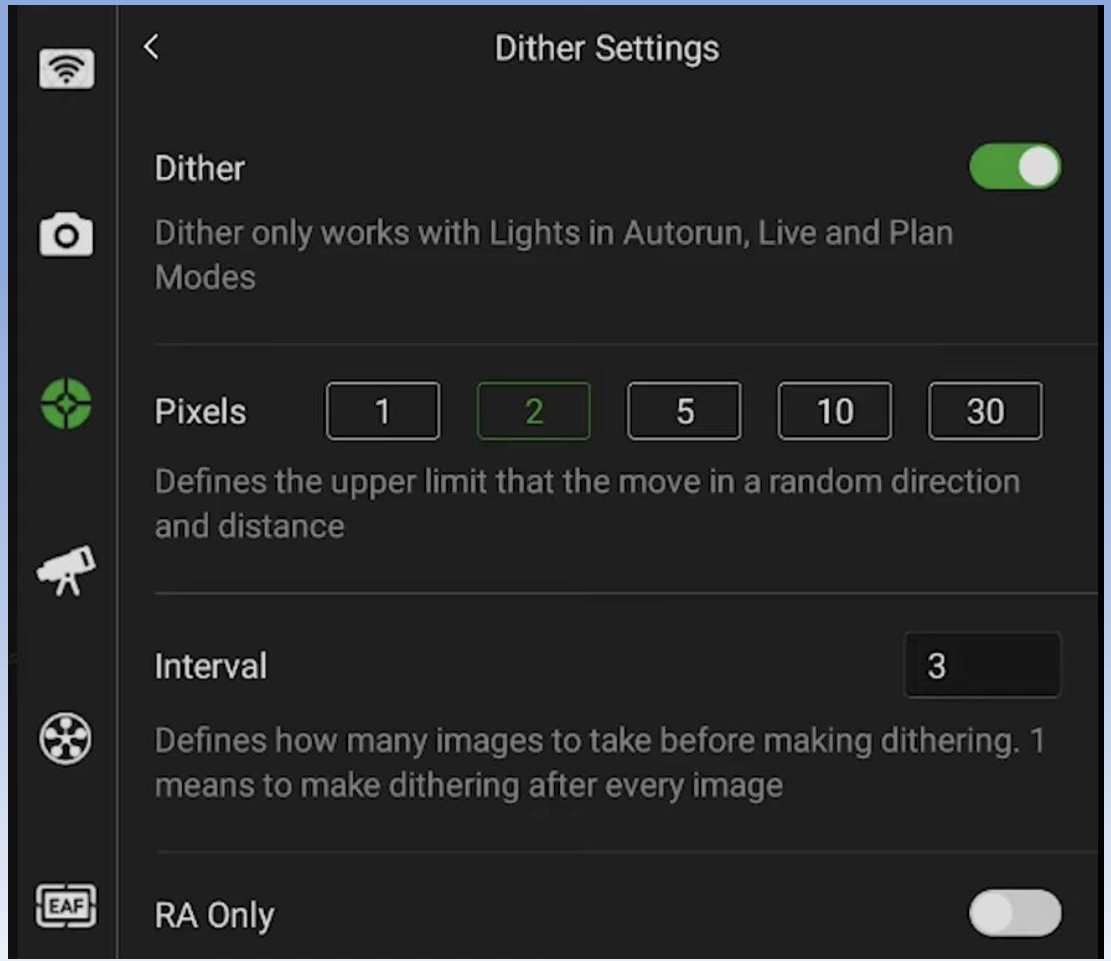
21.5 / 3.09 = 6.96.

The guide scope moves 6.96 pixels in its FOV to move the main scope 21.5 arc seconds

How far to dither? An example

NINA, PHD2 let you select a dithering value of 7.

But in ASIAir, what value do you select?

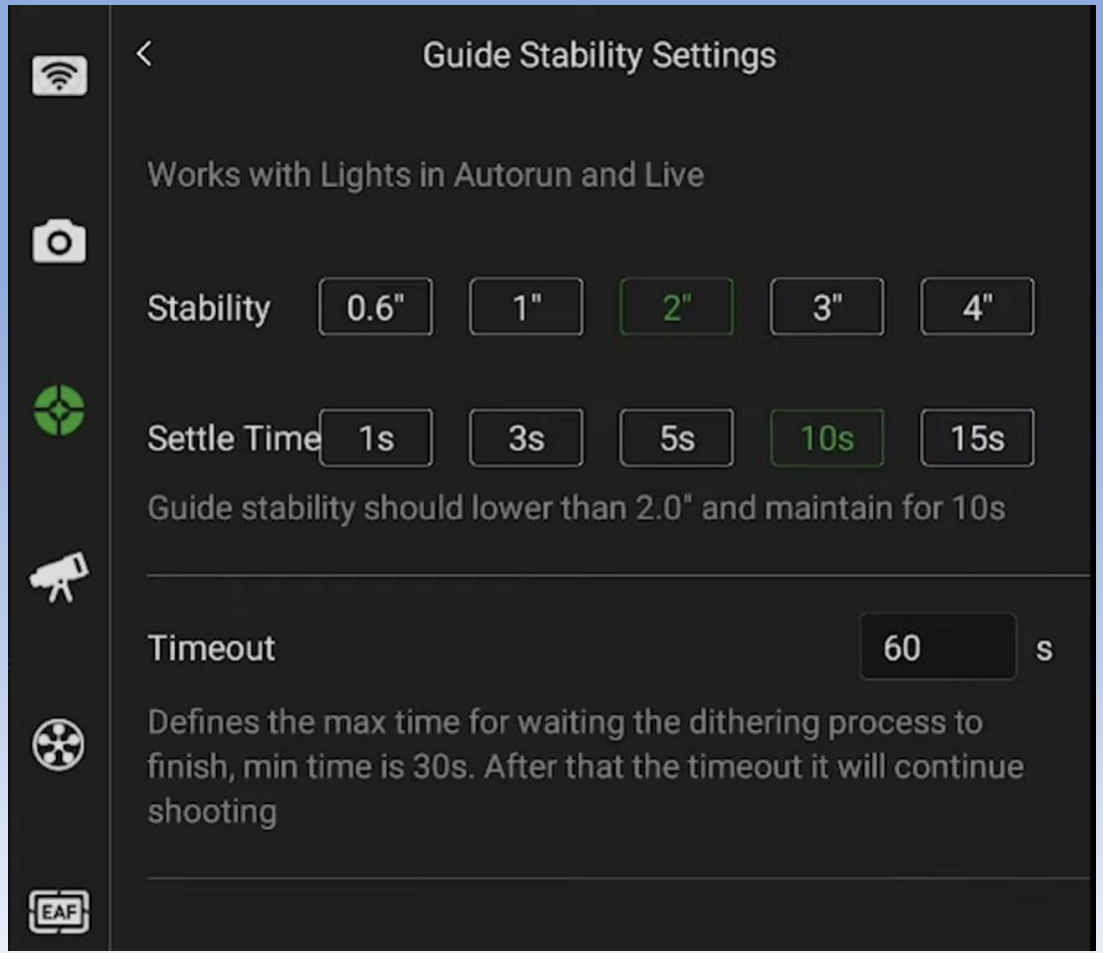

Dither Settings
Dither
Dither only works with Lights in Autorun, Live and Plan Modes
Pixels
1
2
5
10
30
Defines the upper limit that the move in a random direction and distance
Interval
3
Defines how many images to take before making dithering. 1 means to make dithering after every image
EAF
RA Only

How often to dither?

- If you stack many frames before the dither, you will INCREASE to problem
- Stack often. ?every 1-2 frames if long exposures
- ? Longer time before dithering if using short exposures

How often to dither?

- It takes time for the scope to settle down after dithering
- This an overhead to image capture times.
- **How much extra settling time is reasonable????**


Guide Stability Settings
Works with Lights in Autorun and Live
Stability
0.6"
1"
2"
3"
4"
Settle Time
1s
3s
5s
10s
15s
Guide stability should lower than 2.0" and maintain for 10s
Timeout
60
s
Defines the max time for waiting the dithering process to finish, min time is 30s. After that the timeout it will continue shooting
EAF

And the downside is????

- Stacked images will often show a noisier band along the top and/or side as they have less pixels stacked in those areas
- BUT you get much reduced noise overall

Can you dither without guiding.????

- If you can move the scope SLIGHTLY between images you will later stack, then yes.
- BUT you should try to keep the dithering randomly around a star

Does dithering replace darks?

- Darks will remove most of the fixed pattern noise.
- The combination of darks and dithering greatly improves stacked images

If you Dither then you can Drizzle?

- A process that uses data that has been dithered to increase the image resolution
- S50 does this to create 4K images
- Another time for this topic.

2 Image Stacking

Combining exposures to beat the noise floor

Image Stacking

WHAT IS IMAGE STACKING?

- Combining multiple sub-exposures into a single, higher-quality image
- Each sub contains real signal (target) plus random noise (sensor + sky background)
- Signal adds constructively; random noise partially cancels out with each added frame
  - SNR improves as √N — doubling SNR requires 4× the number of sub-frames
- Stacking also removes single-frame artefacts:
  - Hot pixels, cosmic rays, satellite and aircraft trails
- Typical sub counts: 50–200+ depending on target brightness and sub exposure length

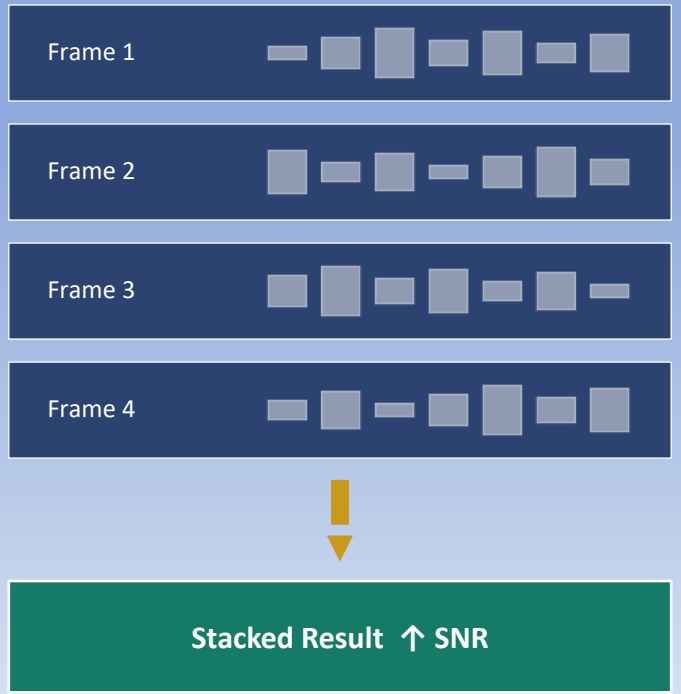


Image Stacking

STEPS DURING THE STACKING PROCESS

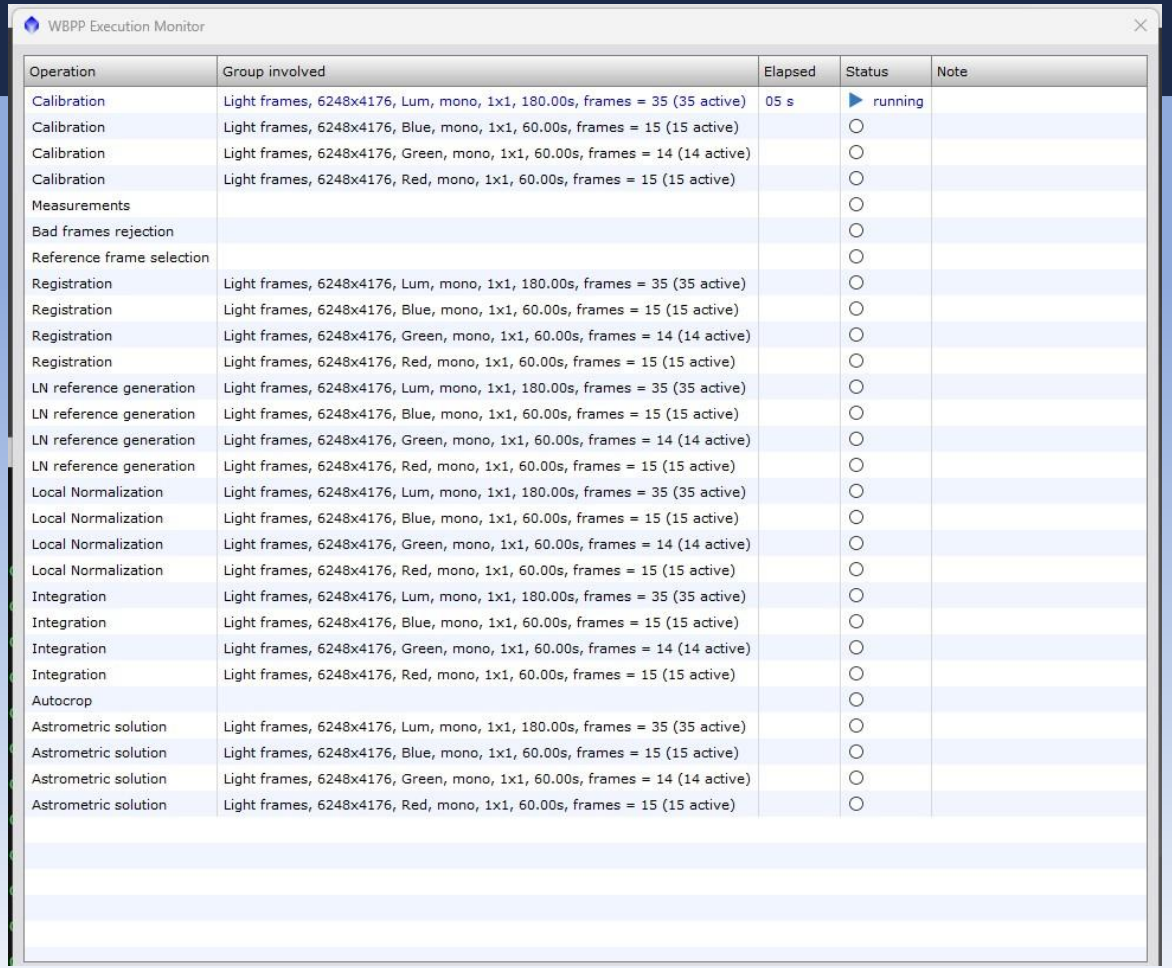
- Before stacking: file selection and review. Reject poor subs before stacking — use quality criteria (eg FWHM, eccentricity, and SNR thresholds etc) in stacking software
  - A few excellent subs outperform many mediocre ones — don't stack everything automatically
- Calibration – dark, bias, flat frames
- Registration – correct alignment of objects in the frames
- Stacking/integration – combining the individual frames into a master image

Image Stacking

STEPS DURING THE STACKING PROCESS

PixInsight WBPP

(Weighted Batch Pre Processing)



Operation	Group involved	Elapsed	Status	Note
Calibration	Light frames, 6248x4176, Lum, mono, 1x1, 180.00s, frames = 35 (35 active)	05 s	running	
Calibration	Light frames, 6248x4176, Blue, mono, 1x1, 60.00s, frames = 15 (15 active)			
Calibration	Light frames, 6248x4176, Green, mono, 1x1, 60.00s, frames = 14 (14 active)			
Calibration	Light frames, 6248x4176, Red, mono, 1x1, 60.00s, frames = 15 (15 active)			
Measurements				
Bad frames rejection				
Reference frame selection				
Registration	Light frames, 6248x4176, Lum, mono, 1x1, 180.00s, frames = 35 (35 active)			
Registration	Light frames, 6248x4176, Blue, mono, 1x1, 60.00s, frames = 15 (15 active)			
Registration	Light frames, 6248x4176, Green, mono, 1x1, 60.00s, frames = 14 (14 active)			
Registration	Light frames, 6248x4176, Red, mono, 1x1, 60.00s, frames = 15 (15 active)			
LN reference generation	Light frames, 6248x4176, Lum, mono, 1x1, 180.00s, frames = 35 (35 active)			
LN reference generation	Light frames, 6248x4176, Blue, mono, 1x1, 60.00s, frames = 15 (15 active)			
LN reference generation	Light frames, 6248x4176, Green, mono, 1x1, 60.00s, frames = 14 (14 active)			
LN reference generation	Light frames, 6248x4176, Red, mono, 1x1, 60.00s, frames = 15 (15 active)			
Local Normalization	Light frames, 6248x4176, Lum, mono, 1x1, 180.00s, frames = 35 (35 active)			
Local Normalization	Light frames, 6248x4176, Blue, mono, 1x1, 60.00s, frames = 15 (15 active)			
Local Normalization	Light frames, 6248x4176, Green, mono, 1x1, 60.00s, frames = 14 (14 active)			
Local Normalization	Light frames, 6248x4176, Red, mono, 1x1, 60.00s, frames = 15 (15 active)			
Integration	Light frames, 6248x4176, Lum, mono, 1x1, 180.00s, frames = 35 (35 active)			
Integration	Light frames, 6248x4176, Blue, mono, 1x1, 60.00s, frames = 15 (15 active)			
Integration	Light frames, 6248x4176, Green, mono, 1x1, 60.00s, frames = 14 (14 active)			
Integration	Light frames, 6248x4176, Red, mono, 1x1, 60.00s, frames = 15 (15 active)			
Autocrop				
Astrometric solution	Light frames, 6248x4176, Lum, mono, 1x1, 180.00s, frames = 35 (35 active)			
Astrometric solution	Light frames, 6248x4176, Blue, mono, 1x1, 60.00s, frames = 15 (15 active)			
Astrometric solution	Light frames, 6248x4176, Green, mono, 1x1, 60.00s, frames = 14 (14 active)			
Astrometric solution	Light frames, 6248x4176, Red, mono, 1x1, 60.00s, frames = 15 (15 active)			

Image Stacking

STEPS DURING THE STACKING PROCESS

WBPP steps

- Calibration – flats, darks, bias to remove sensor artefacts
- Measurements – examines each frame for quality; determines a weighting score for contribution to final image
- Bad Frame Rejection – removes frames with weighting score below threshold
- Registration – aligns all frames to a single, high quality reference frame
- LN Reference Generation – uses 5-10 best frames to determine sky background
  >>> creates a master Reference
- Local Normalisation – equalises brightness variations of every frame, compared to LN Reference
- Integration - combines all calibrated, registered, and normalised light frames into a single, final "Master Light"
- Autocrop
- Astrometric solution

Image Stacking

CALIBRATION FRAMES

- Bias Frames — capture sensor read noise and electronics offset; shortest possible exposure, complete darkness
- Dark Frames — capture thermal noise; must match sub exposure duration, gain/ISO, and sensor temperature. Temperature matching is critical for darks — a 2°C mismatch can leave visible thermal artefacts
  - Cooled dedicated cameras may not need darks if sensor temperature is stable and well-calibrated
- Flat Frames — correct vignetting, dust bunnies, amp glow; shoot against a uniform illumination source
  - Must match the optical path exactly — re-take flats if you rotate the camera or refocus
- Flat Darks / Dark Flats — darks matched to flat exposure time; required by some stacking software
- Stack 20–50 of each calibration type into master frames before applying to light frames

Image Stacking

STACKING METHODS

- Average — adds all frames and divides by N; maximises SNR but no rejection of outliers
- Median — takes the middle pixel value; rejects outliers naturally
  - Lower SNR than average, but effective for small frame counts and satellite trails
- Sigma Clipping (Kappa-Sigma) — rejects pixels that fall beyond N standard deviations from the mean
  - Best all-round choice for 30–200 subs; balances SNR improvement and artefact removal
- Winsorised Sigma Clip — replaces rather than removes outliers; more robust with fewer frames
- Min/Max Rejection — drops the single highest and lowest pixel per stack; good for satellite trails
- Linear Fit Clipping — normalises variable sky backgrounds before clipping; useful for uneven sessions

3

Gradient Reduction

Taming light pollution and uneven backgrounds

Gradient Reduction

WHAT CAUSES GRADIENTS?

- Gradients are uneven brightness across the image background — create unwanted brightness or colour shifts
- Light pollution — sky glow from cities creates a warm brightening, usually toward the horizon
- Atmospheric Conditions - high thin clouds, mist, or airglow can catch artificial light and introduce complex, shifting gradients during a long exposure session
- Vignetting — edges darken due to the optical train; largely corrected by flat frames
- Moonlight — scattered moonlight can produce a strong brightness gradient across the whole frame
- Dew or partial fogging — moisture on the optics creates uneven transmission
- The essential rule: remove gradients on the linear (un-stretched) image
    - Post-stretch gradients are non-linear and far more difficult to remove cleanly

Gradient Reduction

GRADIENT REMOVAL TOOLS AND TECHNIQUES

- PixInsight - Automatic Background Extraction (ABE) ; Dynamic Background Extraction (DBE); Gradient Correction tool (latest); Multiscale Gradient Reduction (comparison to observational data)
- Siril — built-in background extraction
- GraXpert — free, standalone or plugin; AI-powered gradient removal

- Prevention is better than correction:
  - Shoot higher above the horizon; take fresh flats every session; use LP or narrowband filters
  - Narrowband imaging (Hα, OIII) is largely immune to broadband sky-glow gradients

4 Image Stretching

Transforming linear data into a viewable image

Image Stretching

- A freshly stacked image is in a linear state — pixel values are proportional to photon count
- Linear images appear almost black on screen; nebulosity sits just above the noise floor
- This is correct and desirable — it means the data is well-exposed and unclipped
- All calibration work must be done in the linear state before stretching:
  - Colour calibration, noise reduction, gradient removal
  - Once stretched, corrections are far more difficult to apply cleanly
- Stretching is a one-way transform: it expands midtones and compresses highlights

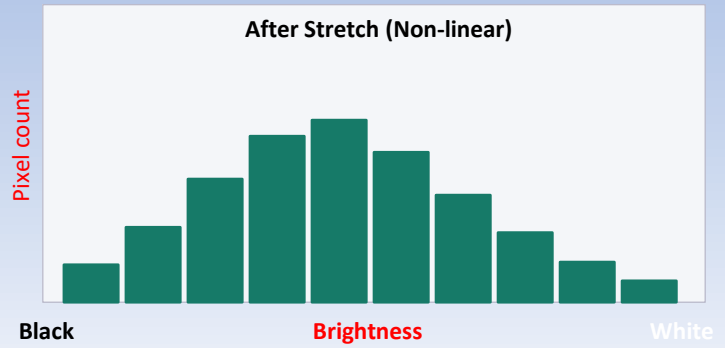


Image Stretching

STRETCHING METHODS

- Screen Transfer Function (STF) - auto-stretch for screen preview only; non-destructive
- Histogram Transformation – basic but effective
- Generalised Hyperbolic Stretch (GHS) — precise control over shadow, midtone, and highlight response
- Arcsinh Stretch — mathematical transform that preserves star colour through the stretch process
- Veralux
- Seti Astro – Statistical Stretch

Image Stretching

TIPS

- Never stretch before: colour calibration, gradient removal, and noise reduction on the linear image
- Stretch gently and iteratively — assess after each pass; it is easy to overstretch.
  Avoid single extreme stretches
- Watch the histogram:
  - don’t drag the left slider too far to the right. This "clips" the shadows to pure black, destroying faint, low-level data.
  - clipping the highlights (right edge) is usually irreversible
- Remove stars then stretch the stars and main target separately, then recombine.
- In LRGB workflows: stretch luminance and the RGB colour data separately for best control
- Colour balance before stretching — minor colour errors are greatly amplified after the stretch
- Not enough signal: if the original image is too noisy (low signal-to-noise ratio), no amount of skilled stretching can fix it. Focus on longer, cleaner, and more numerous exposures.

5 Using Masks

Targeted processing — protect what matters most

Using Masks

WHAT ARE MASKS?

- A mask is a greyscale image applied to your working image that controls where a process takes effect
- A mask divides the image into two parts - full processing effect applied to some pixels, zero effect applied to the rest
- Any processing tool can be applied to the masked (or unmasked) part: noise reduction, curves, sharpening, saturation, colour adjustments
- Without masks, processing operations affect the entire image uniformly — rarely what we want, eg noise reduction that improves the background will also destroy fine star and nebula detail if unmasked
- Available in most photo processing applications

Using Masks

TYPES OF MASK

- Luminance Mask — derived from image brightness; bright areas processed, dark areas protected
  - Effective for sharpening highlights and bright nebula structures selectively
- Colour mask – applies adjustments to a selected colour range; useful for saturation adjustments
- Star Mask — isolates stars as white on black; used to protect stars or to process them exclusively
  - PixInsight: StarXTerminator or StarNet; Siril: dedicated star mask tool
- Range Mask (PixInsight) — selects pixels within a defined luminance or colour range; very precise
- Gradient mask - a selective mask that applies adjustments gradually across an image, transitioning smoothly from fully applied to not applied at all.
- Binary mask - defines a precise boundary around a target

Using Masks

MASK USES

- Noise reduction without destroying detail
- Selectively sharpening nebula structure
- Boosting colour saturation:
  - Apply saturation with a range mask on midtones only — avoids amplifying background noise
- Golden rule: always preview the mask before applying — confirm white/black placement is correct
  - PixInsight: mask preview toggle; Photoshop: Alt-click the mask thumbnail in the Layers panel

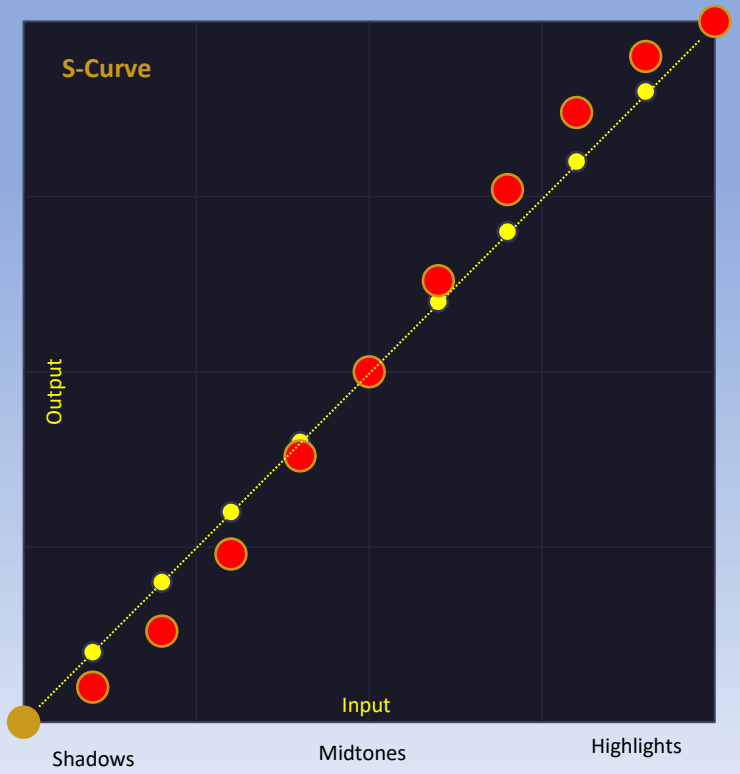
6 The Curves Tool

Possibly the most versatile processing control in your toolkit

The Curves Tool

HOW THE CURVE TOOL WORKS

- Maps input brightness values (x-axis) to output values (y-axis) for every pixel
- The default diagonal = no change: each input level maps identically to the output
- Pull a control point upward: that tonal range is brightened
- Pull a control point downward: that tonal range is darkened
- The S-curve: darkens shadows and brightens highlights, increasing midtone contrast
  - Pull shadows slightly below the diagonal; pull highlights slightly above it
- Apply to combined RGB (overall brightness) or to each R, G, B channel individually



The Curves Tool

THE CURVES TOOL IN PRACTICE

- Midtone lift — single point pulled up; brightens nebulosity without clipping highlights
- S-curve — classic contrast boost; brings out structure while preserving shadow and highlight detail
- Per-channel colour correction:
  - Red channel: raise midpoint slightly to warm star colours and emission nebula tones
  - Green channel: lower slightly to correct the green cast common in OSC cameras
  - Blue channel: boost for reflection nebulae; lower slightly to warm the overall colour balance
- Always work gently in multiple passes — one aggressive curves adjustment causes posterisation and banding