Guiding for Deep Space Astrophotography
(a survey of various resources)

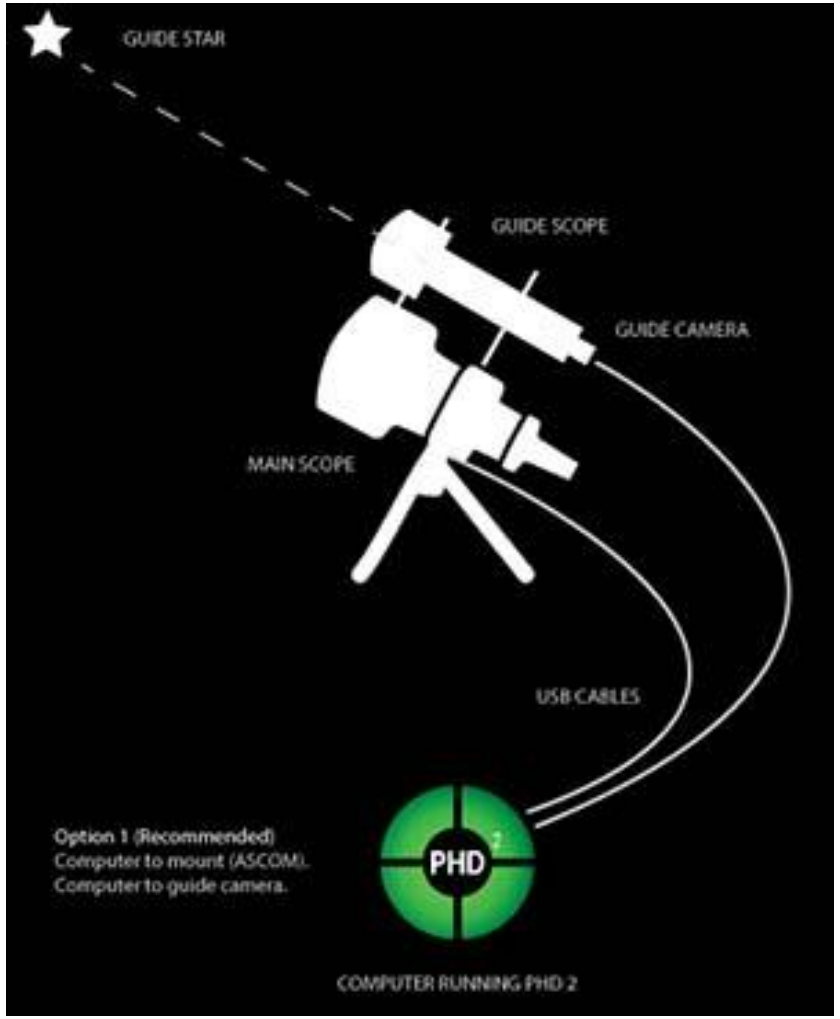

Photo Credit: astrobackyard.com

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Guiding for Astrophotography

- What is Auto Guiding
  - Utilization of small corrections to the position of an equatorial mount during long-exposure imaging
  - The guider follows a bright star and teaks the mount's position so that the star remains in a fixed position in the image

- Why Guide?
  - Mechanical imperfections in equatorial mounts result in tracking errors that lead to slightly elongated stars and smeared images of nebulae and galaxies
  - Becomes an issue with exposure times greater than about 30 seconds
  - Guiding does not correct for poor polar alignment, large tracking errors caused by a poor-quality mount, or sudden errors caused by wind or bumps

Photo Credit: telescope.net

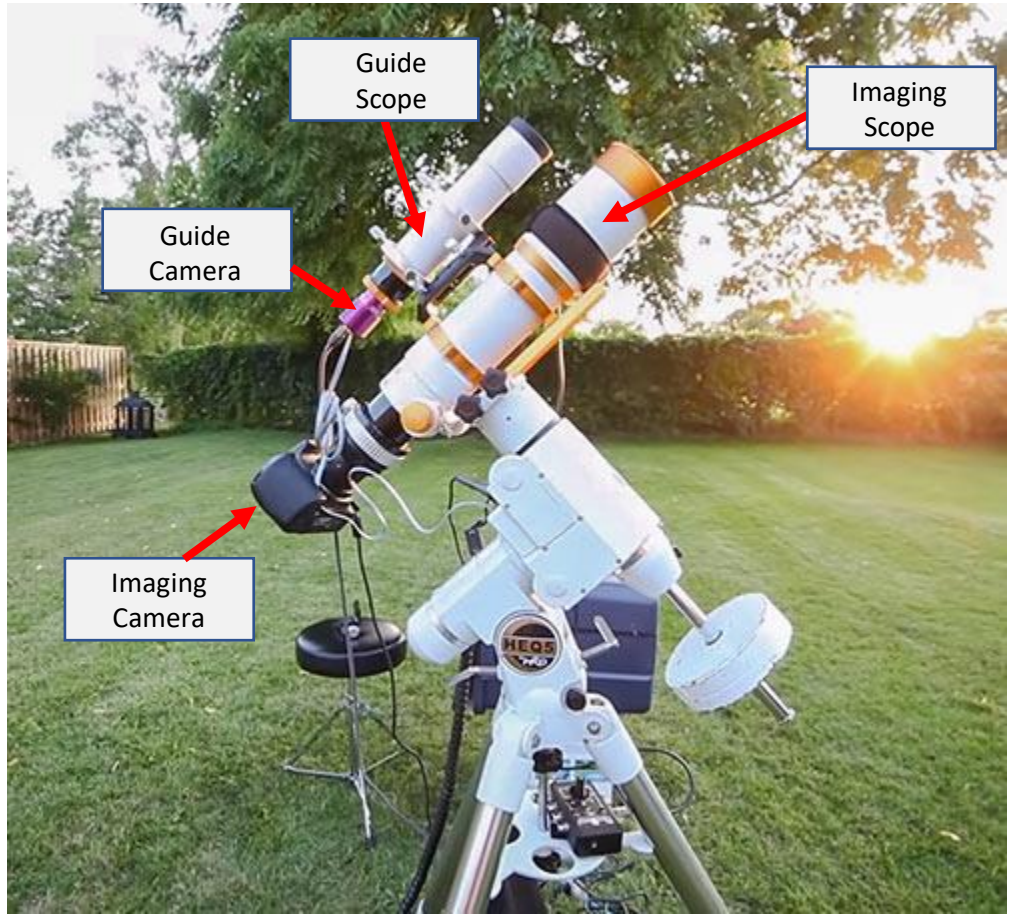
- Guiding Options
  - A separate guide scope and guide camera
  - An off-axis guider (OAG) that directs a portion of the light collected by the main telescope to a separate guide camera

Guidescope vs OAG

	Guidescope	OAG
Pros	• Easy to set up • Plenty of guide stars visible • Easily interchangeable between scopes	• Very accurate • Allows autoguiding of any mirror flop • Will stay in focus with your imaging camera
Cons	• Suffers from differential flexure (need rigid mounting system) • May not be sufficiently accurate at focal lengths > 1000-1500 mm • Cannot guide out SCT mirror flop • Guide Camera focus	• Difficult to set up (debatable) • May lack sufficient guide stars at very long focal lengths • Prism adjustment

Photo Credit: cloudynights.com

Typical Guidescope Set-up



Typical OAG Set-up

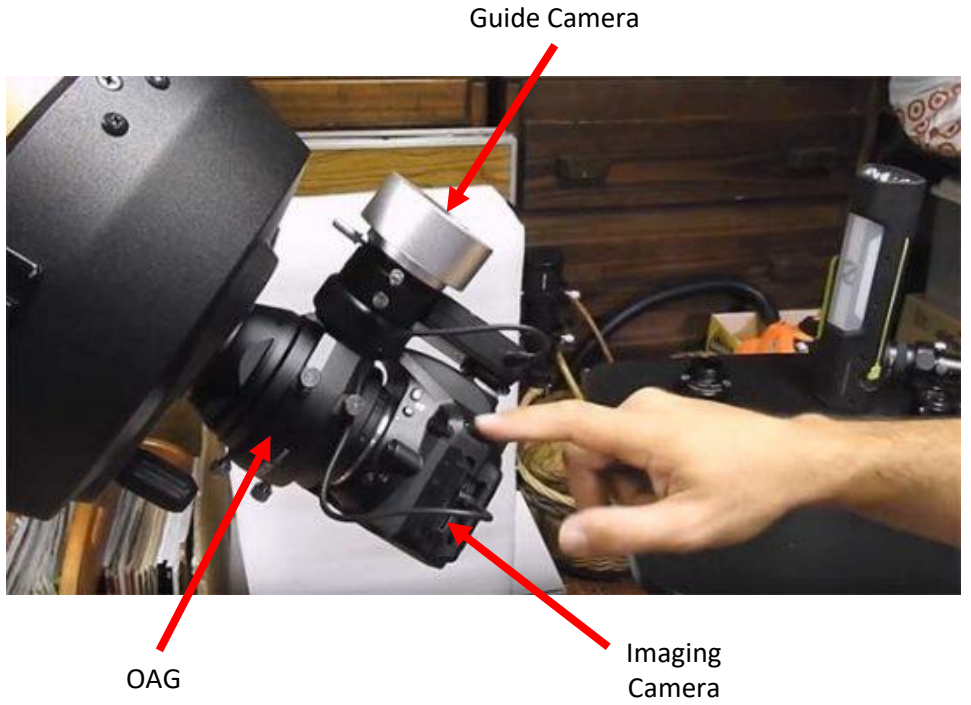


Photo Credits: astrobackyard.com

Celestron OAG

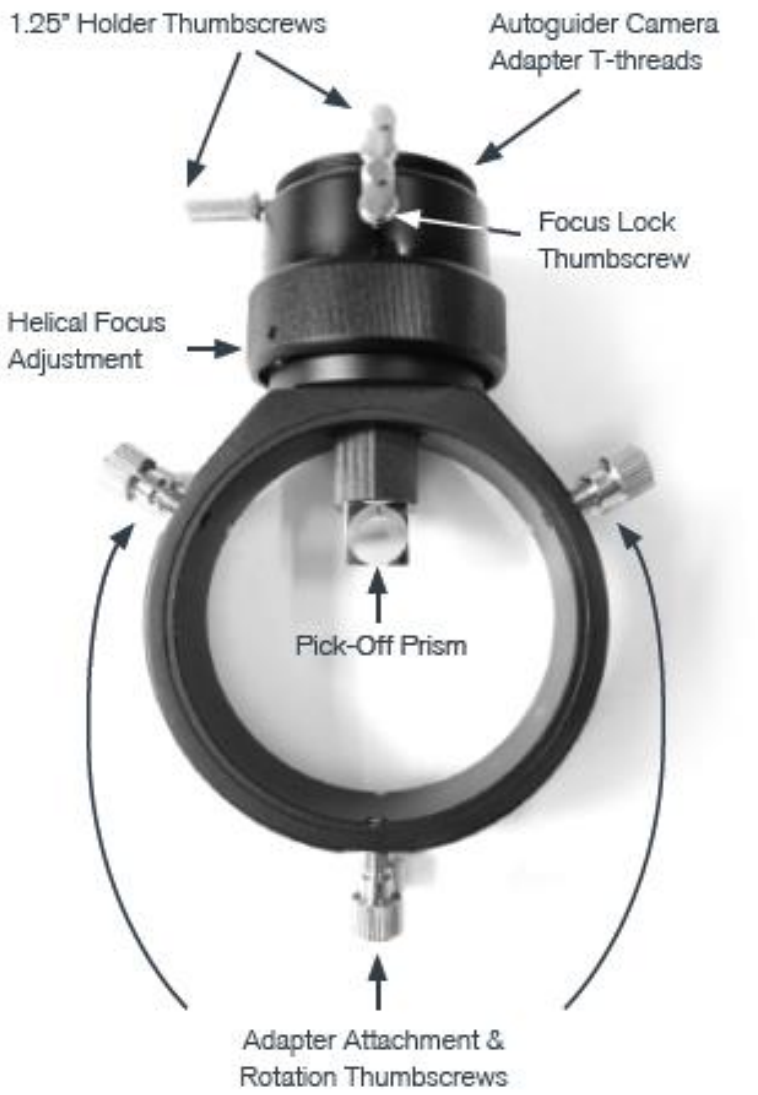
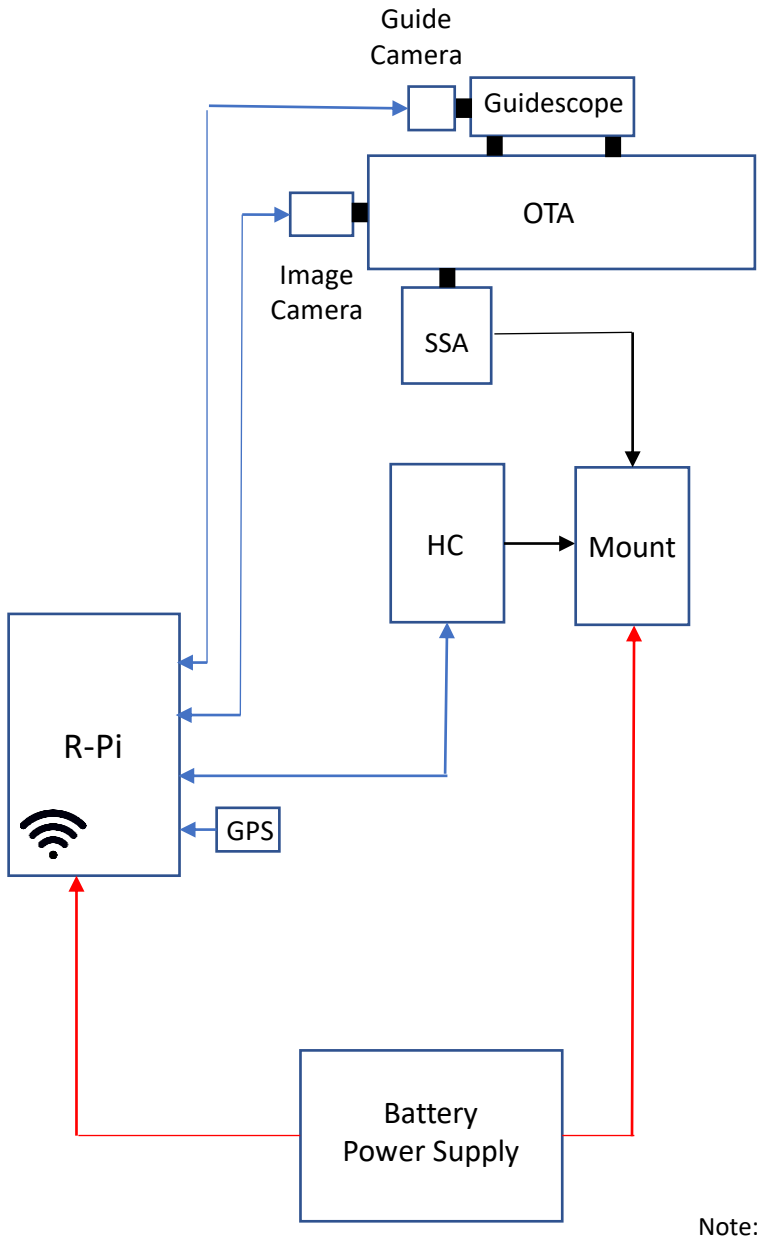


Photo Credits: Celestron

Equipment
Block Diagram
(work in progress)



Note: Pulse Guiding method – does not use ST-4 connection

Mount: CGEM II

OTA: Edge 8” HD

Alignment Aid: Celestron Star Sense Auto Align (SSA)

Imaging Camera: Canon 80D DSLR (unmodified)

Control Computer: Raspberry Pi 4B (4GB)

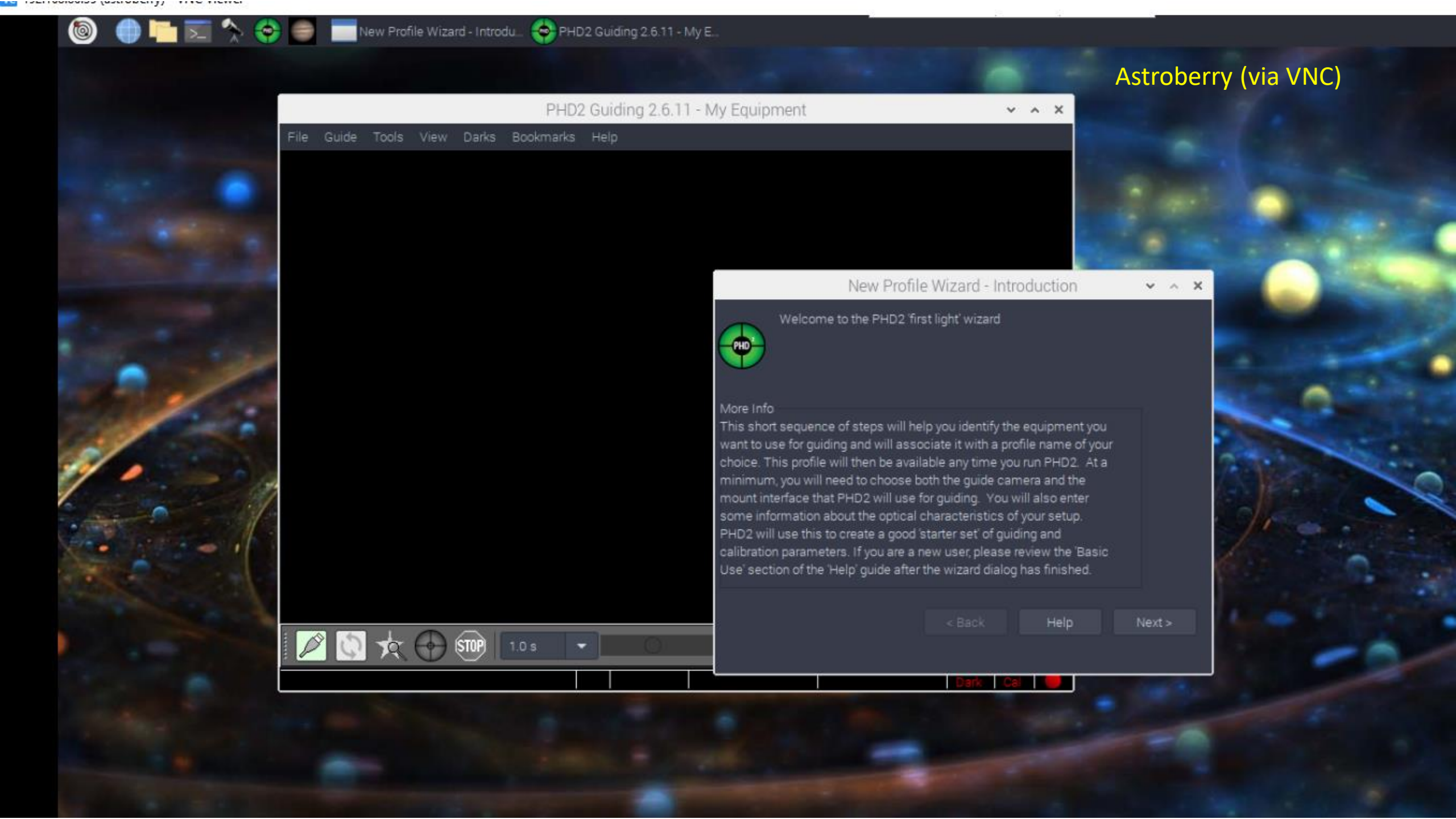
Control/Guiding Software: Astroberry (EKOS, PHD2, etc.)

Guide Camera: ZWO ASI 224MC (color)

Guidescope: TBD

Power Supply: EcoFlow River (288Wh)

Communication: RealVNC


New Profile Wizard - Introdu...
PHD2 Guiding 2.6.11 - My E...
Astroberry (via VNC)
PHD2 Guiding 2.6.11 - My Equipment
File
Guide
Tools
View
Darks
Bookmarks
Help
STOP
1.0 s
Dark
Cal
New Profile Wizard - Introduction
Welcome to the PHD2 'first light' wizard
More Info
This short sequence of steps will help you identify the equipment you want to use for guiding and will associate it with a profile name of your choice. This profile will then be available any time you run PHD2. At a minimum, you will need to choose both the guide camera and the mount interface that PHD2 will use for guiding. You will also enter some information about the optical characteristics of your setup. PHD2 will use this to create a good 'starter set' of guiding and calibration parameters. If you are a new user, please review the 'Basic Use' section of the 'Help' guide after the wizard dialog has finished.
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Help
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Sizing a Guide Scope/Camera

R = Image Scale Ratio = (Image Scale of Guide Scope)/(Image Scale of Imaging Scope) < 5

Image Scale (arc-sec/pixel) = 206*S/FL
S is the size of the camera pixels in µm, and **FL** is the focal length of the telescope in mm

$R = (S_G * FL_I)/(S_I * FL_G)$

Example #1

Celestron 8 " Edge HD with 0.7 Focal Reducer: FL_I = 1422 mm
Canon 80D DSLR: S_I = 3.7 µm
ZWO ASI 224 MC (as a guide camera): S_G = 3.8 µm
FL = 300 mm
R = 4.9

Example #2

Same as above except
ZWO ASI 290MM Mini (guide camera): S_G = 2.9 µm
R=3.7

Guide Camera Selection Considerations

- High sensitivity to allow for short exposures and smaller aperture and lighter guide scopes
- A monochrome sensor for better resolution and sensitivity
- Low noise
- Minimal "hot pixels"
- Compact and lightweight
- Powered by the USB data connection
- Fast download rates (at least USB2.0)
- A built-in ST-4 guiding port to connect the guide camera directly to the equatorial mount (optional, computer-to-mount vs USB/RS232…is preferred)
- Larger sensor to give a wider field of view and more potential guide stars (but a diagonal of 6-7mm probably good enough)

Guiding Summary

- Review listed references and/or explore further to increase knowledge
- Use guiding to allow longer image exposure times without star trailing or target blurring
- Guidescope approach probably better for beginners but can be problematic for longer focal length
- Research installation approaches and accessories, especially achieving correct backfocus
- Select specific guide scope or OAG model and guide camera
- Select preferred computing/control devices
- Consider where you want to monitor the rig from, given your observing location(s)
- Test/improve Wi-Fi (or ethernet) connection between rig and observer’s locations
- Install and learn software for rig control, guiding, etc.
- Practice

References

Autoguding a Telescope (Astro Back Yard)

Agena Astro Selecting a Guidescope and Camera

Optcorp Article on Guiding

Backfocus Solutions (ZWO)

Using PHD2 Guiding (Open PHD)

AstroExploring: Downloading and Installing Astroberry

Using Astroberry for Astrophotography (Ekos Overview)

AstroExploring: PHD2 Guiding