Anatomy of an Imaging System

What toys do you need to take long exposure deep sky images?

Session 1

Anatomy of an Imaging System
3 separate sessions:

1. This session describes the hardware and software in general terms
2. PC software integration and demo
3. Mac/Unix Raspberry Pi software integration and demo

Simple tracked DSLR

You may want to start simple:

Great for *beginning and* ***wide field***. Relatively inexpensive path into astrophotography (while avoiding star trails).

- Camera
  - Your own DSLR
- Mount
  - Your own tripod +
  - a *polar tracking mount*
  - e.g. Skywatcher Star Adventurer, iOptron SkyTracker Pro, Fornax Mounts LighTrack II, etc.

- A good review of the options at https://astrobackyard.com/star-tracker-astrophotography/

Motorized Alt/Az mount can be used too

Orion ST80A f/5 refractor
Celestron SLT GoTo Mount
ASI224MC (ASI120MC-S)

But this is why we all end up at long focal length, long exposure, guided imaging

Hardware overview

- Camera
  - DSLR
  - CCD
- Optics
  - Telescope
  - Camera lens
- Mount
  - Equatorial
- Guiding system
  - Guider
  - Guide scope
  - Off axis guider
- Computer

You will want software to control things

- Telescope mount control
- Camera control
- Guiding
- Plate solving (optional but useful)
- Integration platform

HARDWARE

Cameras

- CCD/CMOS dedicated astro-imaging camera
  - Usually offers cooling and lowest dark current noise
  - Slightly wider spectral response
  - Generally preferred for scientific work as there is no unknown processing applied in-camera to the data
  - Not useful for much else
- DSLR
  - Can take long exposures in the tens of minutes
  - Usually supports video – useful for planetary work
  - Generally limited red response unless modified
  - Not cooled
  - Produced very acceptable images
  - Useful for other imaging endeavours

Optics

- Camera lens
  - Limited aperture
  - Limited focal length
  - Convenient
  - Great for wide field work
  - To get nice stars requires an expensive lens
  - Not as sharp as a telescope in the center of the field
- Telescope
  - Easy to change the focal length
  - Bigger aperture
  - Generally narrower fields
  - Can be expensive, but reflector designs less so
  - Sharper in the center of the field than most camera lenses

Mount

- May be the **most** critical component in the system
- Must be equatorial or use a field derotator for long sub-exposures
- **MUST** be solid
- PEC useful, but not required if guiding
- Accurate GOTO capability very useful
- Computer interface almost a requirement
- Good polar alignment routine a godsend, even in permanent setup
- Be prepared for the cost ($1500 for a light scope)
- Skimping on capability here **will** lead to very frustrating nights under the stars

Guiding system

- Consists of guide camera and either guide scope or off axis guider
- Guide scope offers most flexibility in finding guide stars
- Off axis guider prevents differential flexure problems from mirror flop or a sloppy focuser

Off Axis Guider

- Small prism picks off light from the edge of the field and sends it to the guide camera
- Can only guide on a star at the edge of the field
- As focuser or mirror moves, so does the guide star on the guide camera and the error is removed by the guide camera

Guide Scope

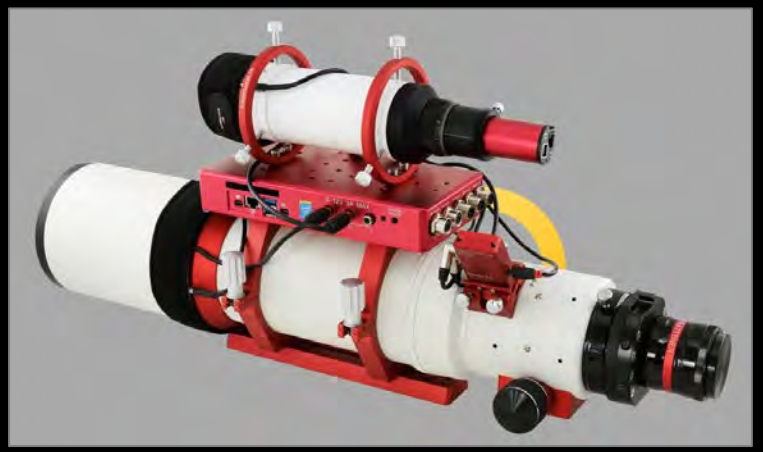
- Allows easy selection of guide star, especially if connected to a guide scope mount instead of rings
- For shorter focal lengths even a finder can be used with sub-pixel guide cameras

Guider

- Almost any camera can be used
- Dedicated units typically offer better sensitivity for using dimmer guide stars
- Orion SSAG and Lodestar are very good

Computer

- Fast processor is not generally needed except if plate solving required
- Plenty of memory as some of the image files are large >100 MB
- SSD or SD card much better than spinning hard drive, especially in the cold
- LCD displays can have issues when cold
- Tablet computers running Windows work very well as do several dedicated, but more expensive systems such as the Eagle
- A Raspberry PI will do the job if you have one with enough memory
- Need lots of USB ports or a hub



SOFTWARE

PC Software You Want / Need

- Planetarium software
  - Many packages available
  - ECU written by our own member Dave Lane works well and comes with great support because we know where he lives
- Telescope / mount control software or drivers
- Camera control software
  - Lots of packages available, most CCD systems come with supporting software
  - Backyard EOS and Nikon work well for DSLR's
- Guiding software
  - PHD rules here, but there are others
- Plate solver
  - AstroTortilla is a bit tricky to set up, but integrates well with some camera software
- Integration solution
  - ASCOM is the most developed
  - INDI is becoming more useful
- All in one solutions are less flexible than an ASCOM solution
  - *NINA* is a free open-source PC only app that incorporates *all* these features https://daleghent.com/nina-introduction

MAC and Linux software

There are *fewer* commercial software packages for OS X and Linux systems…

- Planning & Observation:
- AstroPlanner
- Observatory
- Cartes du Ciel
- SkySafari 6 Pro

- Planetarium & Scope Control:
- CloudMakers AstroTelescope
- Stellarium
- **KStars with EKOS**
- SkySafari 6 Pro
- Starry Night
- TheSkyX
- AstroGrav

- Capturing & Processing:
- **ASTAP**
- Astro Pixel Processor
- Stark Labs Nebulosity
- PixInsight
- CloudMakers AstroImager
- CloudMakers AstroDSLR
- CloudMakers AstroGuider
- PHD2 Guiding
- Open Astro Project
- Lynkeos
- Keith's Image Stacker
- StarTools
- FireCapture
- SiriL
- Planetary Imager
- ASTAP
- CCDciel
- StarStaX
- Startrails Creator
- AstroImageJ

- Utilities:
- CloudMakers FITS Preview
- CloudMakers INDI Control Panel
- CloudMakers INDI Server
- CloudMakers Astrometry
- Collimation Aid
- Darklight
- SER Player
- Nightlight
- QFitsView
- PHD2 Log Viewer

*This is a list for OS X from: https://www.macobservatory.com/mac-astronomy-software/ (some are free)

MAC and Linux software

- There are *fewer* commercial software packages for OS X and Linux systems…

…but there are several *free* packages that provide numerous features.

KStars – based on indi framework https://edu.kde.org/kstars

Astroberry server – https://www.astroberry.io

Indigo – framework layer on top of indi http://indigo-astronomy.org

AstroPi3 – automates installing of KStars and other ancillary packages on numerous platforms https://github.com/rlancaste/AstroPi3

ASTAP - is a free stacking and astrometric solver (plate solver) program for deep sky images.

Stellarmate – *Not free* - prepackaged KStars Raspberry Pi hardware/software/OS ($179) or software only for your own Raspberry Pi ($49)
https://www.stellarmate.com