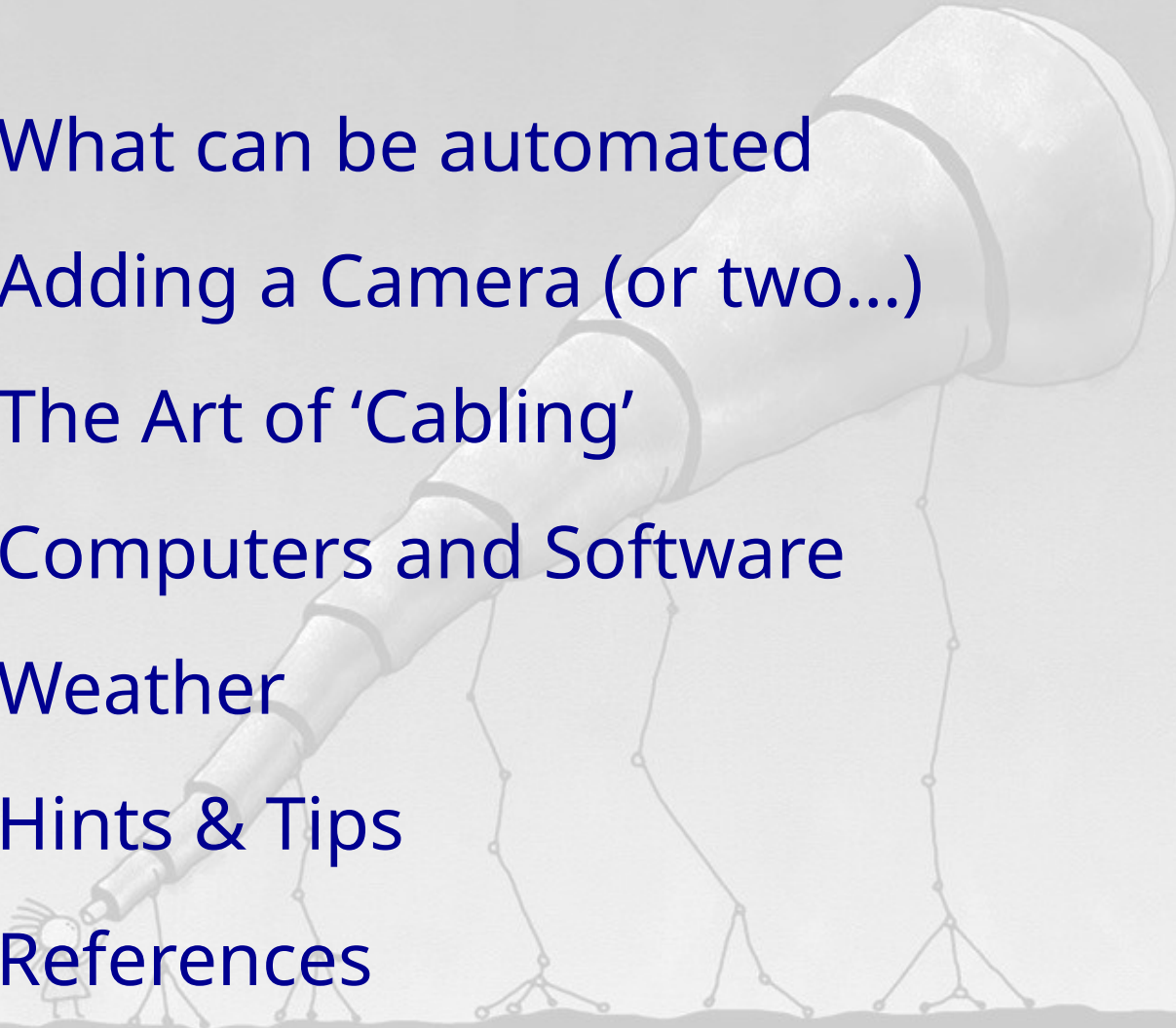
A composite image of space featuring the Earth, the Moon, a galaxy, and numerous asteroids. The Earth is in the lower center, showing continents and clouds. The Moon is in the upper right corner. A galaxy is visible on the left side. Numerous asteroids of various sizes are scattered throughout the scene. The text "Automating your Telescope" is overlaid in the center in a white, sans-serif font.

Automating your Telescope

Sifan Kahale
Hōkū Wahine

Automating your Telescope

- What can be automated
- Adding a Camera (or two...)
- The Art of 'Cabling'
- Computers and Software
- Weather
- Hints & Tips
- References



What Can be Automated?

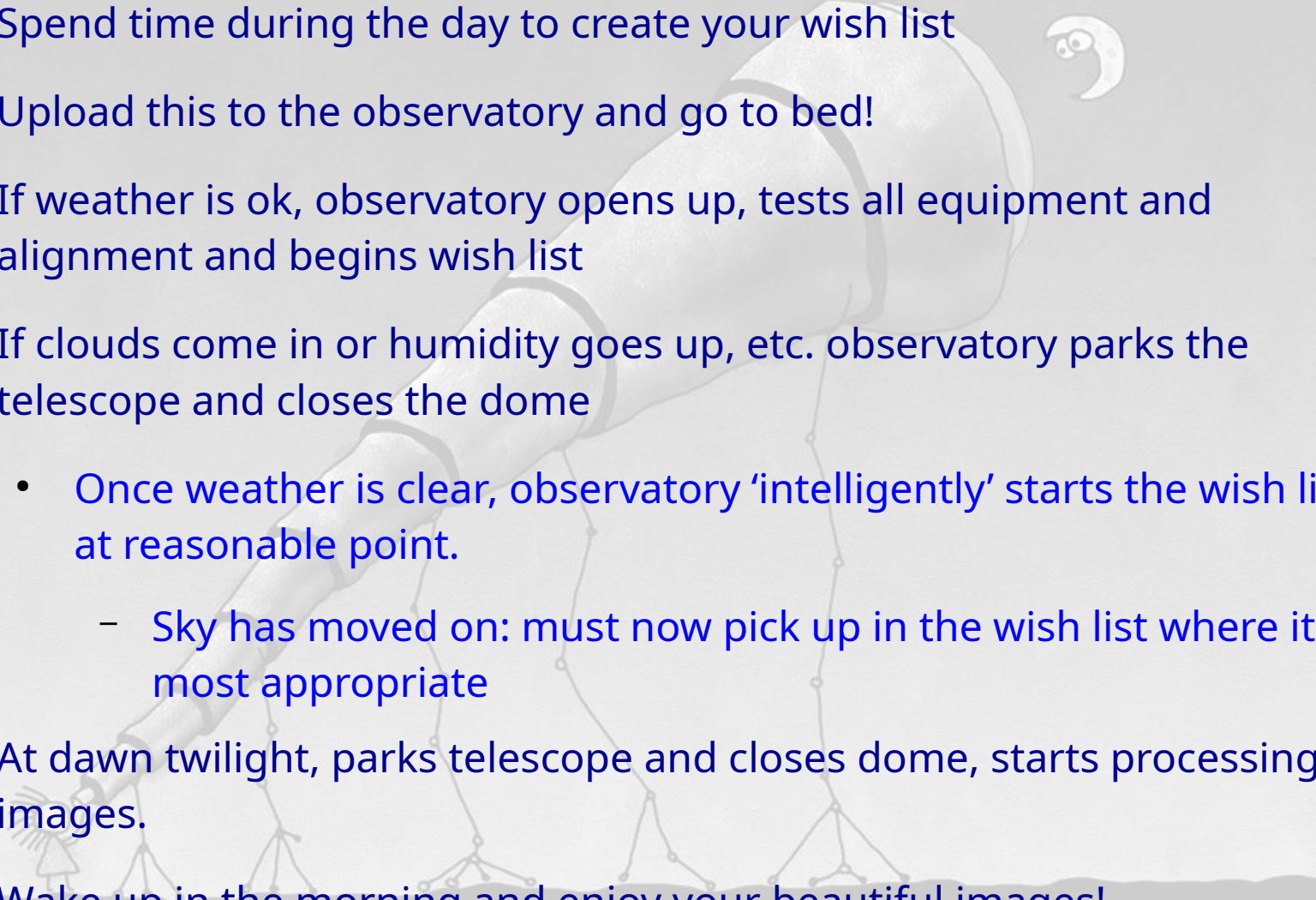
- Mount (slewing and tracking)
- GPS
- Polar alignment
- Focus Motors
- Dew Heaters (esp around here ...)
- Camera
- Auto-Guider
- Filter Wheel
- Power Management
- Sky and Weather Monitoring
- Dome
- Flats/Aperture Cover



Biggest Bang
For the buck

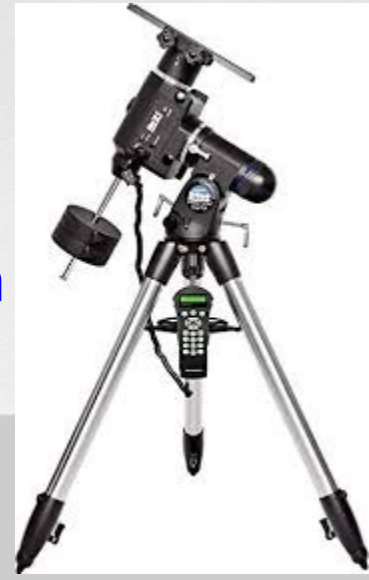
Typically
Proceeds
In this order

Fully Automated Scenario

- Spend time during the day to create your wish list
 - Upload this to the observatory and go to bed!
 - If weather is ok, observatory opens up, tests all equipment and alignment and begins wish list
 - If clouds come in or humidity goes up, etc. observatory parks the telescope and closes the dome
 - Once weather is clear, observatory 'intelligently' starts the wish list at reasonable point.
 - Sky has moved on: must now pick up in the wish list where it's most appropriate
 - At dawn twilight, parks telescope and closes dome, starts processing images.
 - Wake up in the morning and enjoy your beautiful images!
- 

Mount

- GoTo Mounts (\$500 → \$10,000)
 - USB/RS232/WiFi
 - Connect from computer/laptop/phone
 - 'Click & Slew' from planetarium or sky chart
- Automated Alignment
 - Able to track object much longer
- Mount Model:
 - More alignment stars the better the acquisition
 - Can usually place the target in the FOV!



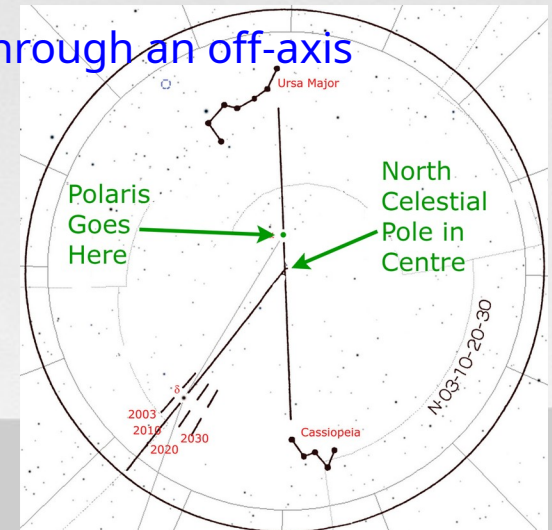
GPS

- The telescope needs to know it's exact location and time.
 - You set this the first time you use your telescope
 - However, you will need to update this info if you travel or go to star parties
- GPS option automates this setup
 - Especially helpful if you change locations frequently



Polar Alignment

- If no dome or permanent mount, then need to do this EVERY time ...!!
- Polaris is about $\frac{3}{4}$ degree away from true north
 - Aligning to Polaris will result in tracking errors for photography
 - Use a polar 'bore-sight' scope, a graduated ocular or perform an off-axis alignment
 - Most GoTo mounts have software to guide you through an off-axis alignment
- \$100 → \$400



Focus Motor

- Oh it's frustrating when you have to wait for the scope to stop vibrating after you barely 'touch' the focus knob ...
- They attach to your focus knob
- USB/WiFi/RS232 port for a computer
- > \$500



Dew Heaters

- That pesky dew ...
- Can extend observing
 - But if not regulated, can cause turbulence by the objective
 - Use a dew heater controller
 - Senses dew point and regulates current to heaters

\$400



\$50



Camera

- Lots of options here
 - DSLR, AstroCam, Phone or Tablet
- Need a way to mount it
 - T-adapter, phone adapter, etc.

\$200 - \$10,000



\$2500



\$30



\$20



\$20



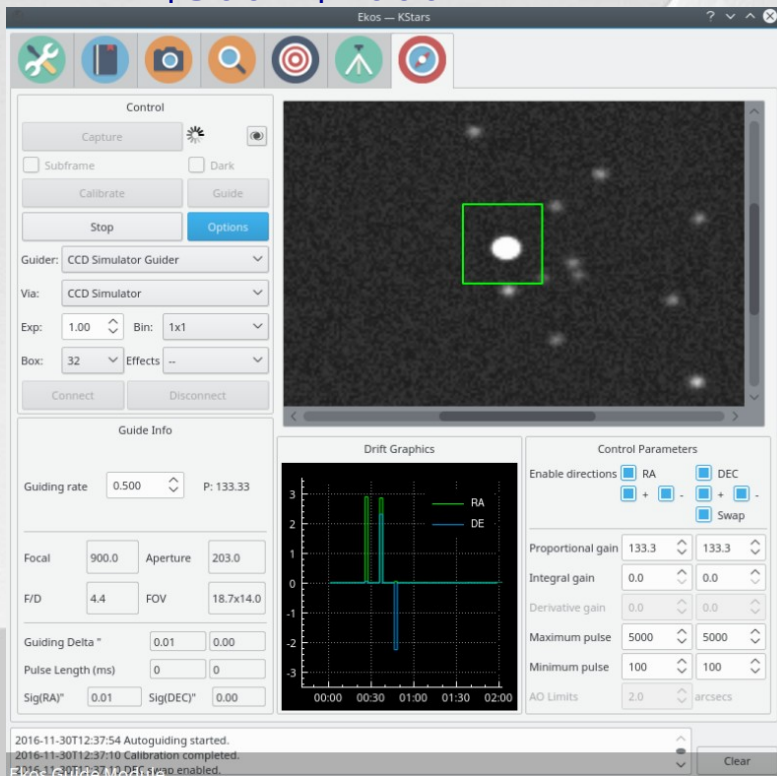
Filter Wheel

- Monochrome cameras are more sensitive and have a larger dynamic range
- You will want a filter wheel to switch between Luminance, Red, Green and Blue filters
 - Perhaps Oiii, Sii and H-Alpha
- Manual: \$79 Automatic: \$250-\$1000
- Filter sets: \$300 - \$5000



Auto-Guider

- Accurately tracks targets
- Small but wide FOV telescope with camera
- Takes image and issues commands to mount to speed up or slow down if a selected star moves
- \$300 - \$1000



Power Management

- Number of devices out there that allow you to remotely power devices (\$600-\$1000)
 - USB, 12V (cameras, mount, filters), Dew Heaters
 - Some incorporate computers
 - Access via wifi and control everything at the site



The 'Art' of Cabling

- Loose cables topple telescopes ...



Sky and Weather Monitoring

- If you are going to do remote observing, then you need to monitor the sky and the weather
 - Perhaps have an auto-close procedure
- Sky Monitoring
 - All Sky Camera
 - Sky Temperature
 - Medical IR temp. sensor pointed at the sky
 - Clouds are warm: $\sim 10^{\circ}\text{C}$, clear sky: -17°C
- Very useful even if you are not automated!



Permanent Pier

Sick and tired of spending ½ hour or more perfectly aligning your mount every time?

Sink in a permanent pier. You can go 'cheap' (sort of) by using a sonotube and pouring your own concrete (\$200), or you can buy one (\$500-\$2000).

Either way, you will need an adapter for the base of your mount (\$300-\$500)



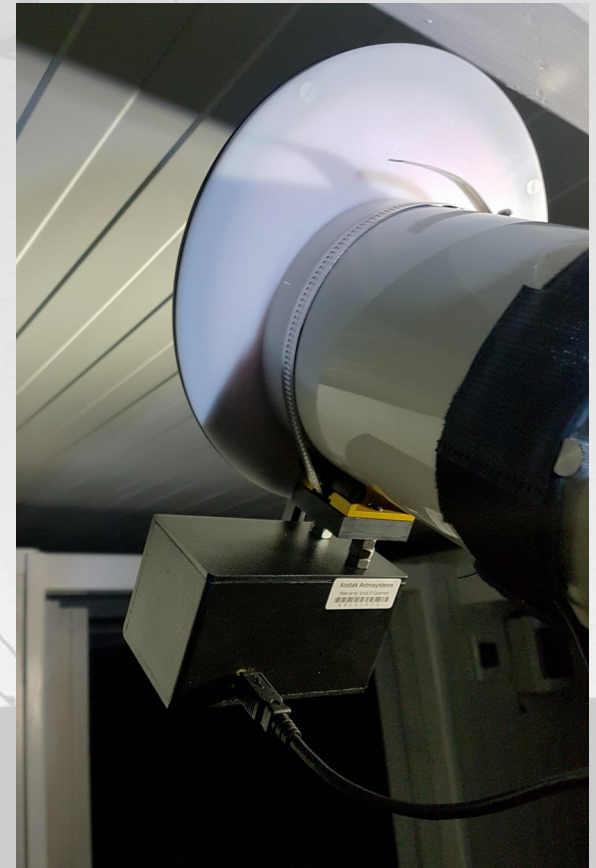
Dome

- Can be quite pricey!
- Two main types:
 - Dome (just the 'top': \$3500)
 - Add option to have it rotate with your mount (\$1500)
 - Add option to have it automatically open the slit (\$1500)
 - RollOff (\$500-\$3000)
 - Option to have it automatically open (\$300)
 - Psst: You still need a pier ...



Flats/Aperture Cover

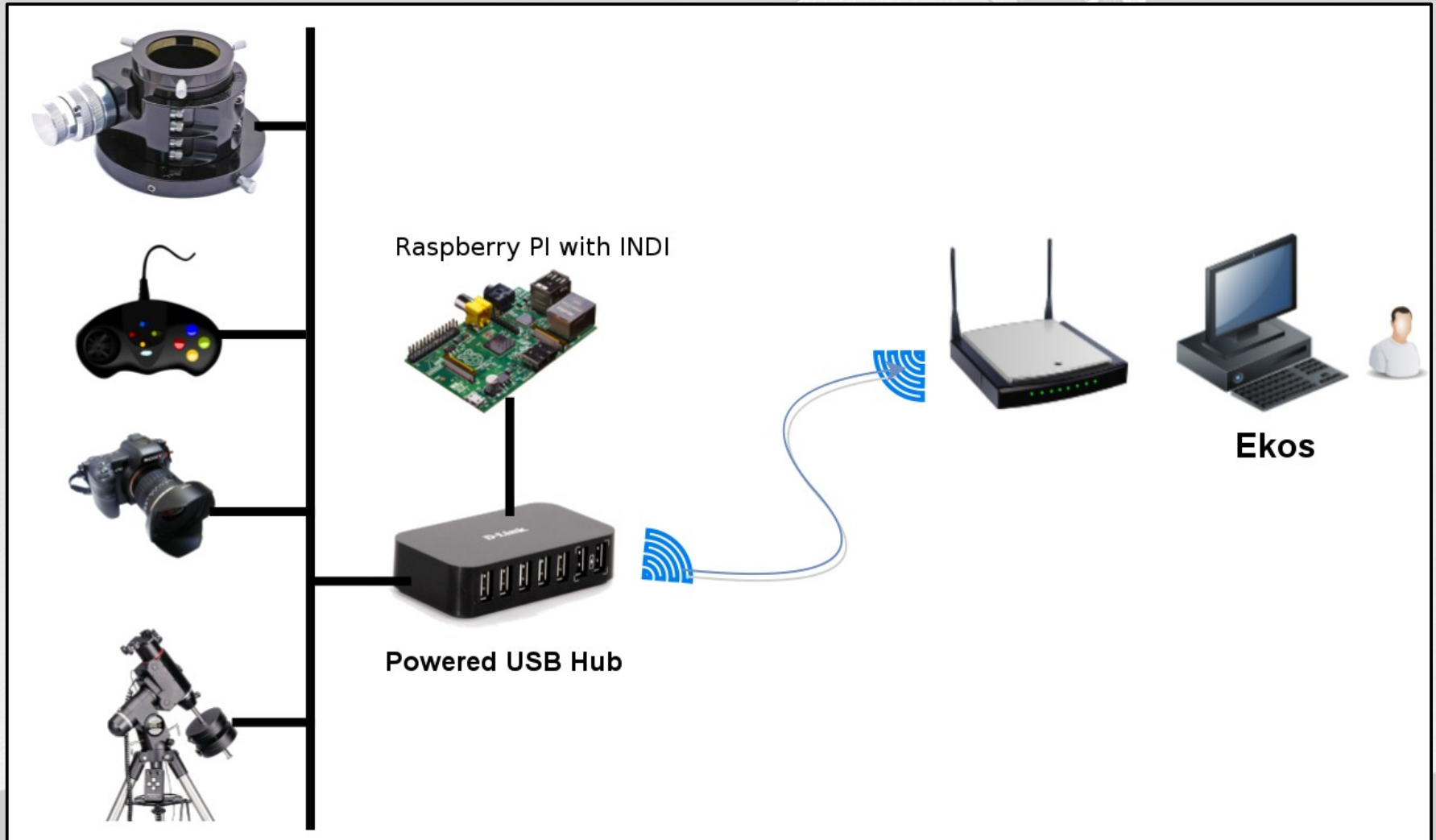
- And, well, you still need to cover the aperture to keep the lens/mirrors clean (\$500)
- Can combine this with flat screen (\$900)



Computers

- For complete automation, there are two main low level 'driver-systems' out there:
 - ASCOM (MS Windows – proprietary/expensive)
 - INDI (Linux – opensource, you can add/change, it's free!)
- Higher level control software can run on anything: Windows, MAC, Linux, Android, etc
- Example: Raspberry Pi (\$50) running Astroberry (INDI - free) at the telescope, Win/Mac/Linux laptop or tablet running the command center.
- Even over the WEB

Connections

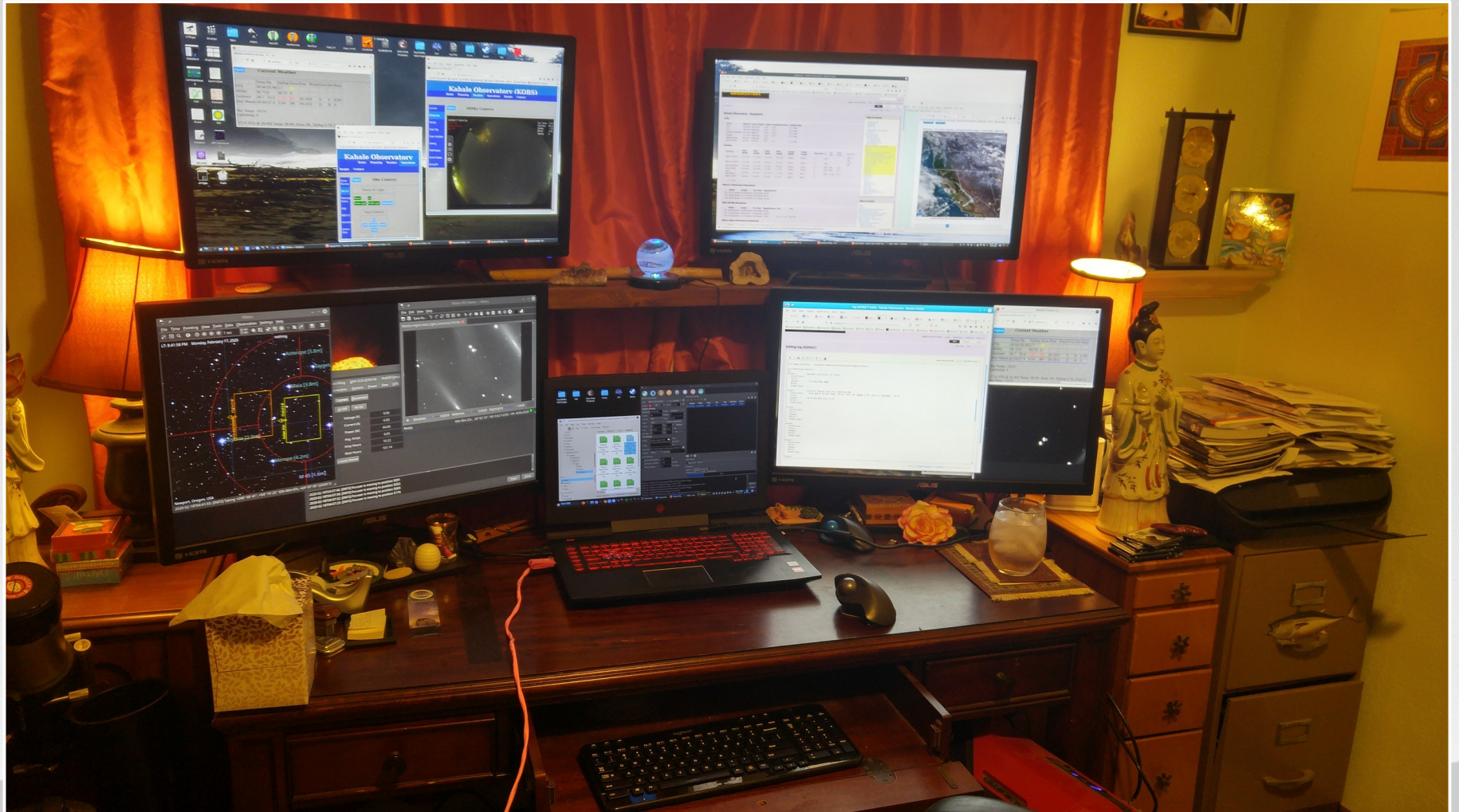


Software Automation

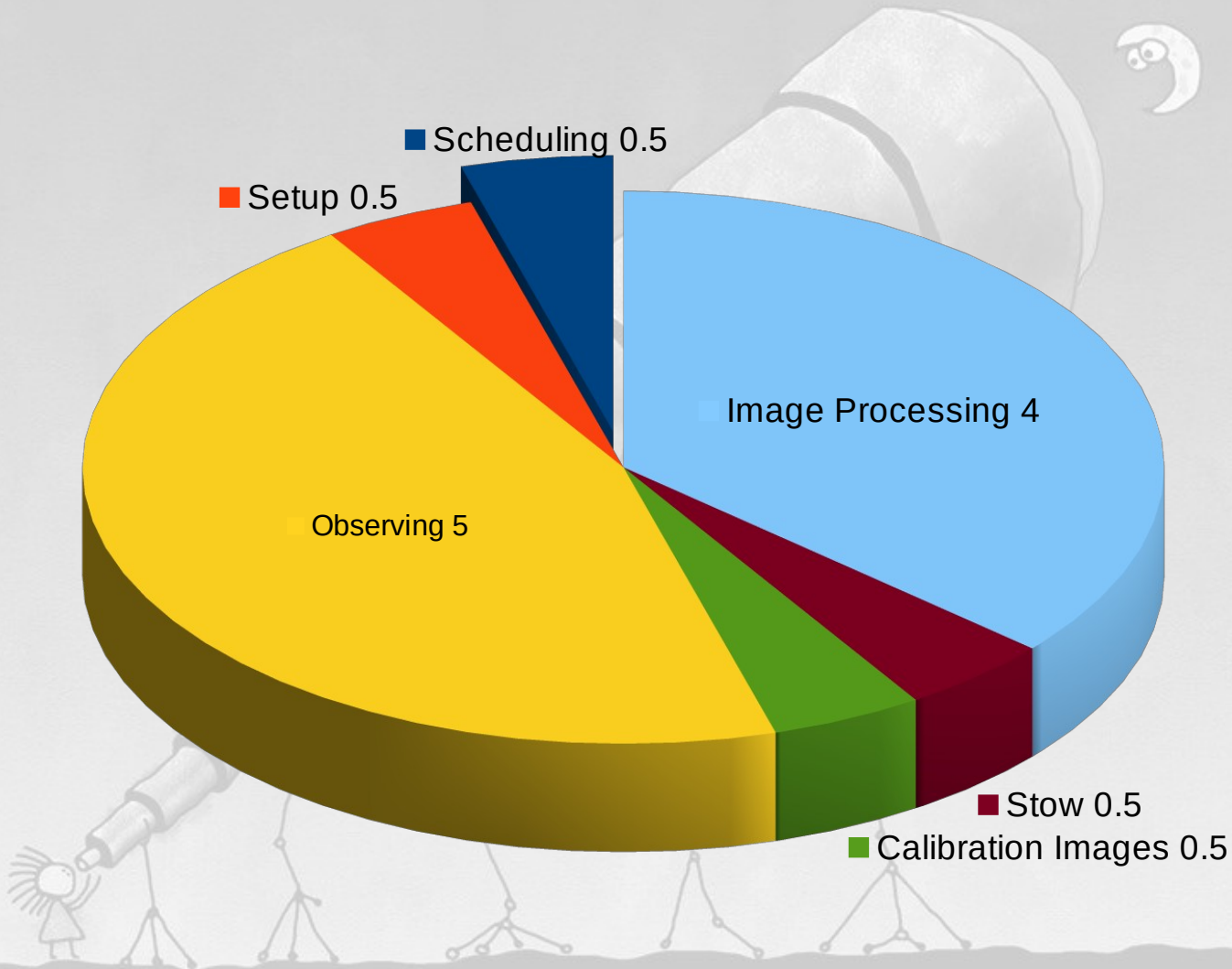
- Alignment
- Plate-Solving: Slewing
- Auto Focus
- Guiding: Tracking
- Target Selection and Scheduling
- Queue/Sequencing
- Auto Shutdown and intelligent restart
- Auto calibration sequence (darks, flats, biases)
- Auto Initialize and Park (telescope and dome)
- Overall observatory monitoring and control




Command Center



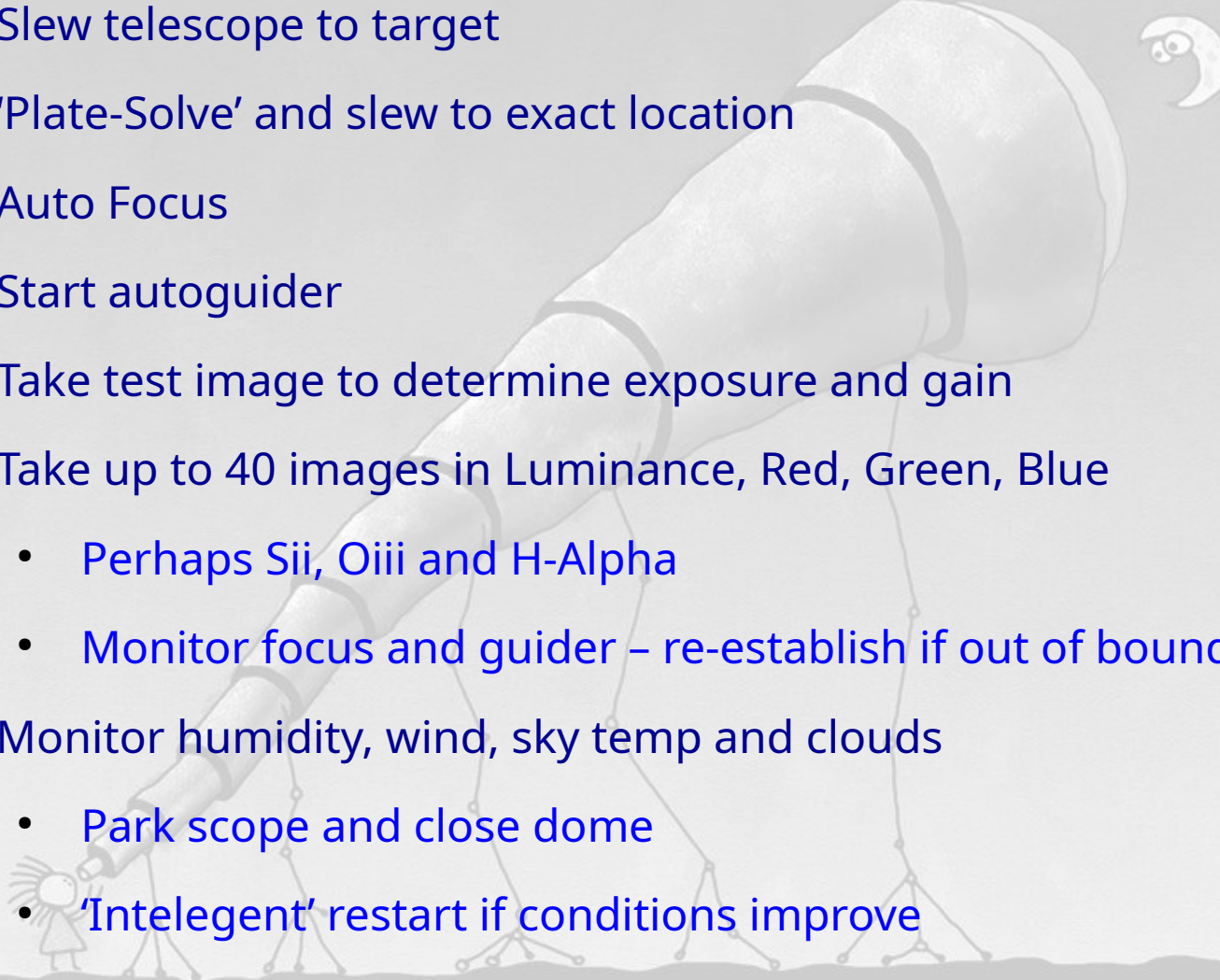
Where Does The Time Go?



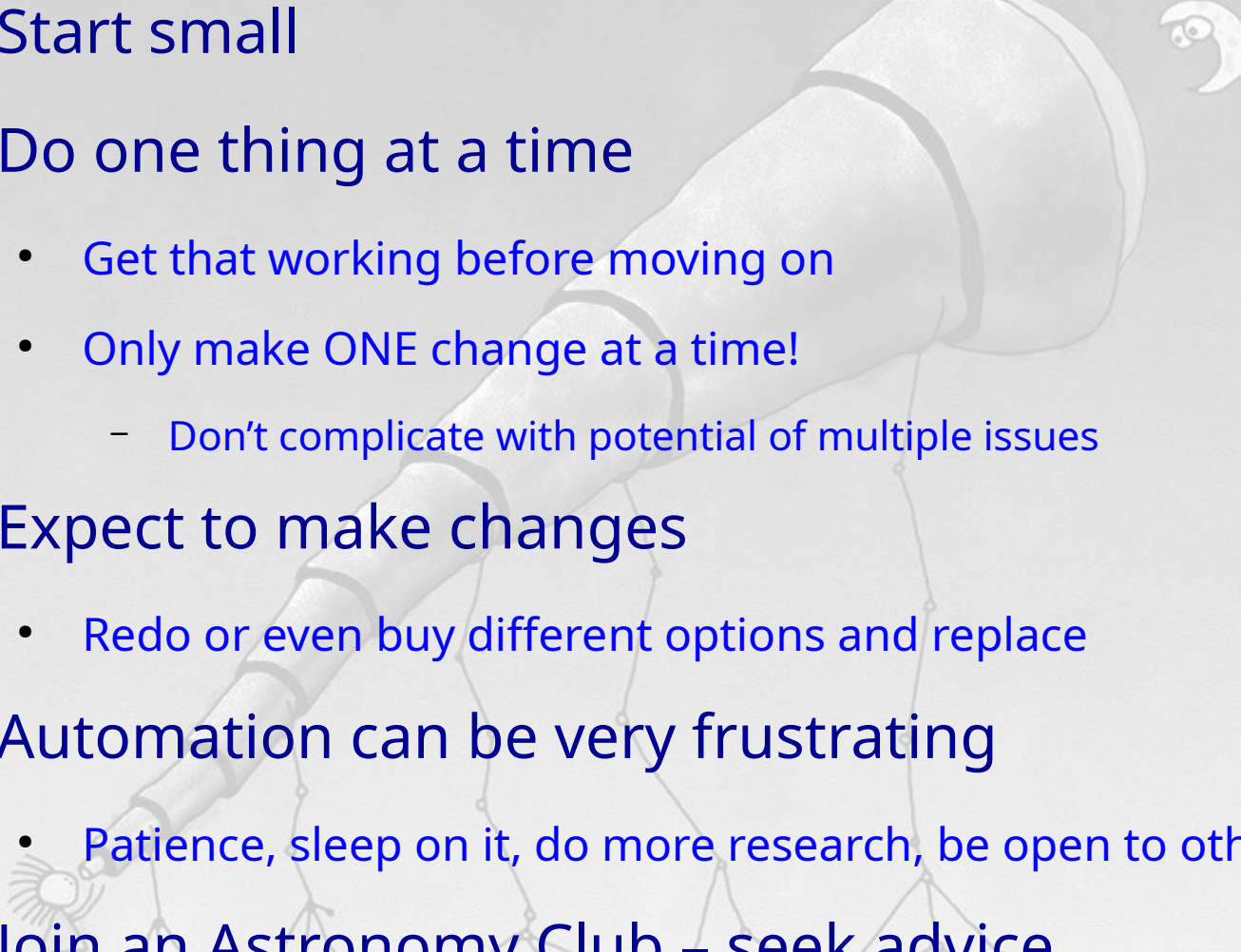
Typical Night

- Late Evening: (skip if dome)
 - Move gear out to position, align roughly to north
 - Twilight: (skip if dome)
 - Align to Polaris then perform accurate alignment
 - Mount Model and Tracking Model
 - Nautical Twilight: Observing (next slide)
 - Morning Twilight:
 - Take bias, flats and darks
 - Put everything away (skip if dome)
 - Daylight or a cloudy night: Process Images
- 
- A faint background illustration of a telescope mounted on a tripod. The telescope is positioned diagonally across the frame. In the upper right corner, there is a crescent moon with a face. In the lower left corner, there is a small sun with a face. The entire scene is set against a light gray background with a dark gray horizon line at the bottom.

Automated Observing Process

- Slew telescope to target
 - 'Plate-Solve' and slew to exact location
 - Auto Focus
 - Start autoguider
 - Take test image to determine exposure and gain
 - Take up to 40 images in Luminance, Red, Green, Blue
 - Perhaps Sii, Oiii and H-Alpha
 - Monitor focus and guider – re-establish if out of bounds
 - Monitor humidity, wind, sky temp and clouds
 - Park scope and close dome
 - 'Intelegant' restart if conditions improve
 - Rinse and repeat ...
- 
- A large, stylized telescope is the central focus, rendered in a light grey, semi-transparent style. A small, simple human figure stands at the base of the telescope, looking up at it. The background is a light grey gradient representing a night sky, with a small crescent moon in the upper right corner. The overall aesthetic is clean and modern.

Hints

- Start small
 - Do one thing at a time
 - Get that working before moving on
 - Only make ONE change at a time!
 - Don't complicate with potential of multiple issues
 - Expect to make changes
 - Redo or even buy different options and replace
 - Automation can be very frustrating
 - Patience, sleep on it, do more research, be open to other ways
 - Join an Astronomy Club – seek advice
- 

Perspective

Don't go crazy about this stuff –
it's a hobby!

!! ALIENS !!

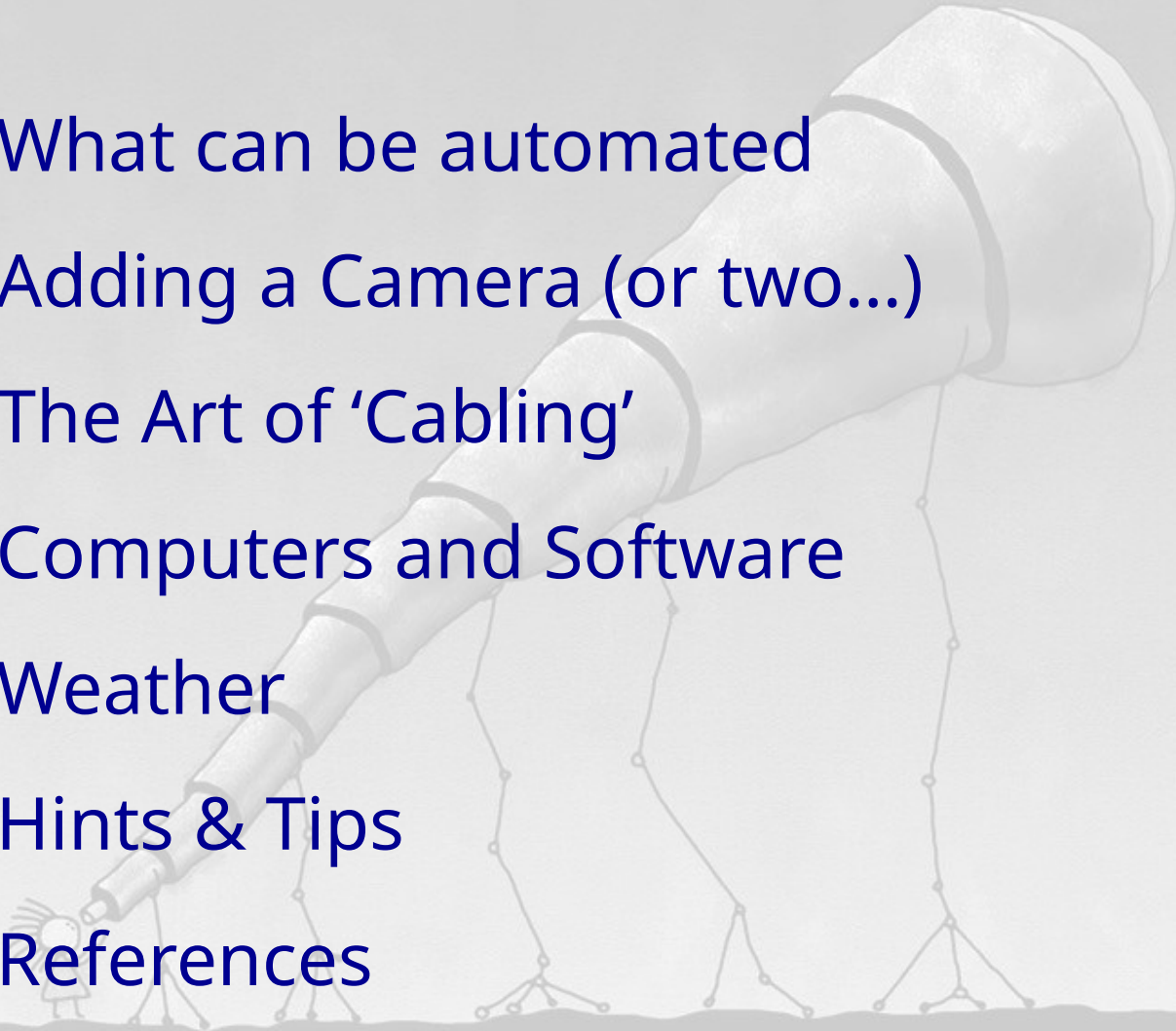


References

- Cloudy Night forum: <https://www.cloudynights.com/>
 - OptCorp: <https://optcorp.com>
 - Orion Telescopes: <https://www.telescope.com>
 - Adorama: <https://adorama.com>
 - HighPoint Scientific: <https://www.highpointscientific.com/>
 - <https://www.skyandtelescope.com/>
 - <http://www.astronomy.com/>
 - <http://clearoutside.com/forecast/44.81/-124.06?view=midnight>
 - <http://www.cleardarksky.com/c/LnclnCtORkey.html?1>
 - <https://www.indilib.org/about/discover-indi.html>
 - <https://indilib.org/devices/raspberry-pi/astroberry-server.html>
 - <https://ascom-standards.org/>
 - Google !!
- 

What We Covered

- What can be automated
- Adding a Camera (or two...)
- The Art of 'Cabling'
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- Hints & Tips
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A composite image of space. In the foreground, the Earth is shown from a perspective that includes the Americas and parts of Europe and Africa, with blue oceans, white clouds, and brown/green landmasses. To the right, the Moon is partially visible, showing its cratered surface. The background is a vast field of asteroids of various sizes and shapes, scattered across the dark space. A bright sun is visible in the upper center, creating a lens flare effect. The Milky Way galaxy is visible on the left side, stretching across the frame. The overall scene is a representation of the solar system's environment.

Mahalo!

Sifan Kahale
Hōkū Wahine
(Star Woman)