Open Source Software For Astronomy

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Who Is This Guy?

- Khalid (“ ... ed” not “ ... eeeeed”)
- Pharmacist by education
- Open Source Software Development and Consulting by experience (32 years)
- One of the developers of Drupal, a Web Content Management System

Who Runs Drupal?

- Government:
  - White House (for over 10 years)
- Media:
  - The Economist
- Academia:
  - Harvard University
  - University of Waterloo (over 600 sites)
- Entertainment: Lady Gaga
- Weather.com

Who Runs Drupal?

- Non Profit
  - KWLUG
- Astronomy
  - NASA
  - RASC

What About Astronomy?

- Interest since middle school and high school (~ 1970s)
- No observing clubs in Egypt (at least then)
- Milky Way in summer (near Alexandria, Egypt)
- Relative making telescopes in 1970s
- Hiatus ...
- Binoculars in the 1990s
  - For Comets (Hyakutake and Hale-Bopp)
- 4.5 inch Bushnell with shaky Alt-Az mount (~ 2001)
- Hiatus ...

What About Astronomy?

- Lake Huron skies + Milky Way (~ 2014/2015)
- Wanted to take it further ...
- Google Sky Android App
- Per advice from a friend: 10 inch Newtonian on Equatorial Mount (April 2016)
- One night mentoring on astrophotography with an experienced life time astronomer (June 2016)
- Bruce Peninsula (end of Aug / early Sep 2016)
- Hiatus (Sept/Oct 2016, then Dec/Jan 2017)

Overview

- Key Observational Astronomy Concepts
  - Sky Movement
  - Coordinate Systems
  - Twilight, Atmosphere, Moon
- Planetarium Software
- Astrometry
- Examples of Telescopes, and amateur images

Key Concepts

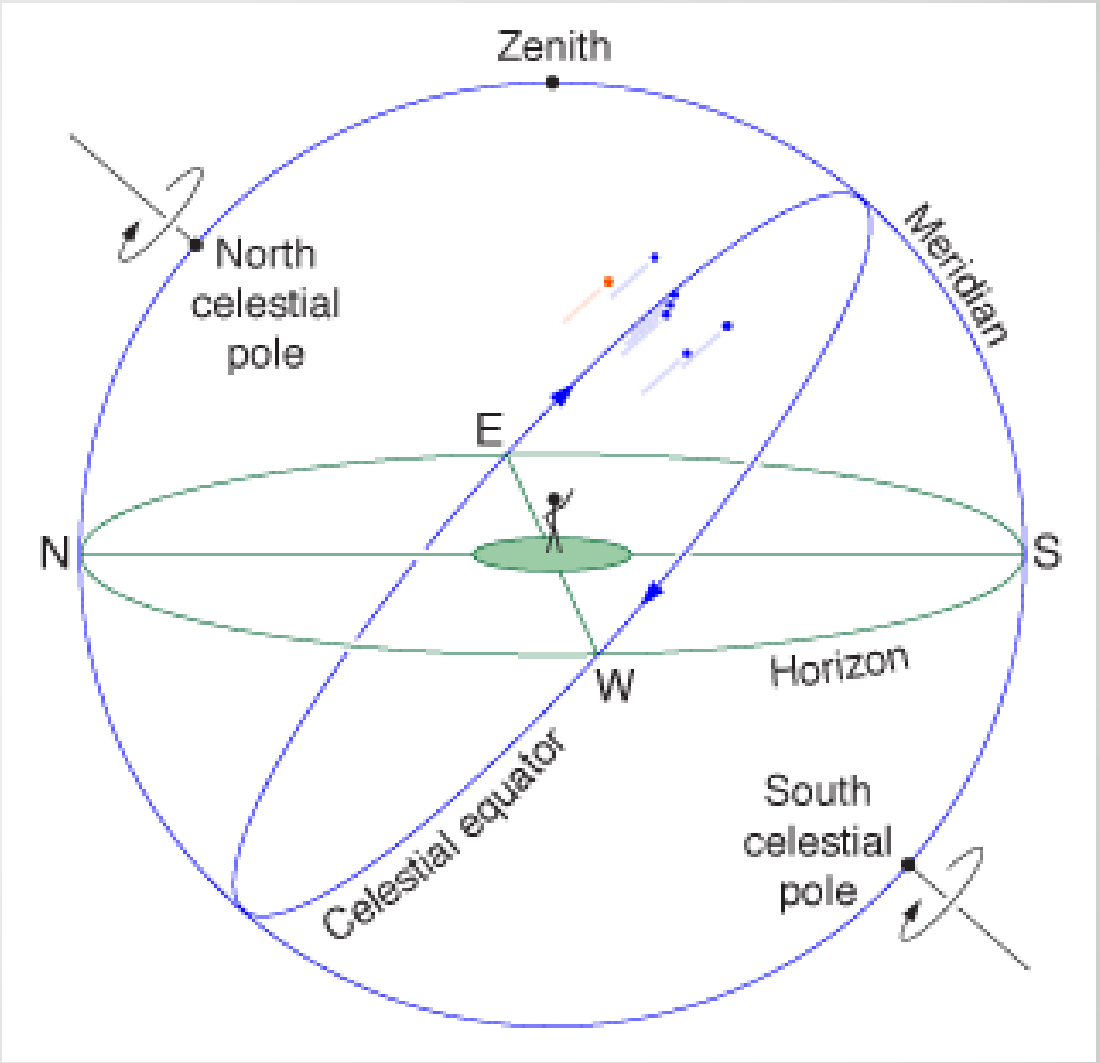
- Observational Astronomy is multi-disciplinary:
  - Physics (celestical mechanics)
  - Trignometry and Spherical geometry
  - Optics (collecting photons)
  - Photography (capturing photons)
  - Mechanics (to cancel the earth's rotation)
  - Electronics (to drive the mechanics and photography)
  - Software (more later)
  - Weather

Sky Motion

- The earth moves in two cycles
  - Daily (sidereal vs. solar, 4 minute less)
  - Yearly (seasons, axial tilt)
- The ‘fixed’ stars (and Constellations) move over the course of
  - A night
  - A year

Sky Motion

- Objects rise in the east and set in the west
- Celestial pole and celestial equator positions depends on the observer's latitude
- Same star rises earlier by ~ 4 minutes every night
- Solar system objects (planets, asteroids, comets) have their own separate cycles



Twilight

- Can’t observe most objects until dark
- Rayleigh Scattering
  - “Why is the sky blue?”
  - No atmosphere = black sky (e.g. moon)
- Sunset is not enough, nor Civil twilight
  - Sun 6 degrees below horizon
- Astronomical Twilight (dark sky starts)
  - 18 degrees below horizon

Moonlight

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- Depends on:
  - Moon Phase
    - Lunar month (29.5 days)
    - Percentage illuminated
  - Time of night
    - Moon rises and sets later every day (~ 50 mins)
    - Until it catches up to the sun when both set at the same time (on new moon)
    - Moon set

Atmospheric

- Cloud Cover
- Transparency
  - Particles in the air (water vapour, smoke, smog)
  - Less = better observing
- Seeing
  - Turbulence in the atmosphere
  - Steady = better observing
- Airmass
  - More air when object is closer to the horizon
  - Higher = better observing

Object Position

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- An object's position in the sky depends on
  - Object's equatorial coordinates
  - Location
    - Latitude
    - Longitude
  - Date
  - Local Time (including Daylight Savings)
    - Offset from UTC
    - Offset from timezone centre
  - Elevation
  - Atmospheric refraction

Coordinate System

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- Altitude/Azimuth
  - Alt: ;Degrees above horizon (+), below horizon (-), 90 is zenith
  - Az: N (0), E (90), S (180), W (270)
- Equatorial
  - Analogous to latitude and longitude, but for the sky
  - Right Ascension
  - Declination (degrees from celestial equator to celestial pole, negative for southern part)

In Summary

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- It's very complicated ...
- Historically required lots of math equations
- We are lucky to have things like:
  - Computerized Ephemeris
    - Predictions of positions for solar system objects
  - Planetarium Software (solar system, and other 'fixed' objects)
  - Goto Telescopes

First Real Scope

- Meade DS-10, mid 1980s
- Equatorial Mount, RA motor only
- No GOTO
  - Great to learn the sky ...
  - Waste valuable observing time ...
- Canon EOS T4i DSLR camera
- All used

Remember ...

- Only 7 months of experience
  - Some much shorter than that ...
- No GOTO
- No autoguiding
- No stacking
- No post-processing
- All prime focus
  - Except for a few with eyepiece projection, 7.5 mm
- Single exposure (mostly 30 seconds, some are 60 seconds)
- JPEG straight from camera

Moon

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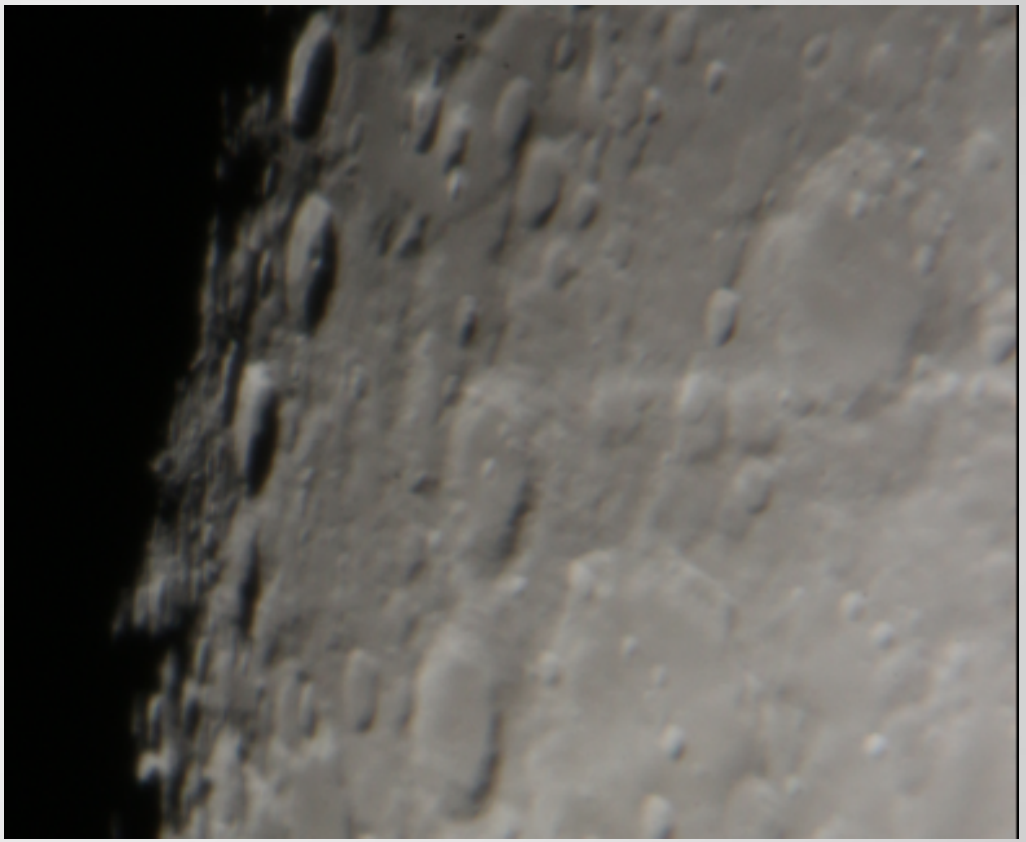
- Eyepiece projection
- 1/30 sec @ ISO 800



Jupiter

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- Eyepiece projection
- 1/16 sec @ ISO 400

Castor A & C

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- Eyepiece projection
- 15 secs @ ISO 1600

Cor Caroli

- Eyepiece projection
- 4 secs @ ISO 1600

M45 Pleiades

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- Open Cluster
- Visible to the naked eye
- 30 sec @ ISO 3200

M13 Cluster in Hercules

- Globular Cluster
- Visible in binoculars as a fuzzy patch
- 30 secs @ ISO 6400

M20 Trifid Nebula

- Visible in binoculars as a fuzzy patch
- Emission and Reflection Nebula, with dust lanes
- 30 secs @ ISO 6400

M42 Orion Nebula

- Winter object
- Visible to the naked eye
- Star forming region
- 30 secs @ ISO 1600

Finding Objects

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How to find things to observe?

Star Charts

- The old fashioned way
  - Books
  - Laminated charts
    - so they don’t get damaged by dew
- Star Hopping
  - A still very useful skill, e.g. naked eye observing, or with binocular

Database Queries

- List of Objects
  - Saguaro Astronomical Club (SAC) database
- Load in MySQL
- SQL queries
- Article on my personal web site (baheyeldin.com)

Planetarium Software

- Free and Open Source
  - Stellarium
  - Cartes du Ciel (SkyChart)
  - KStars

Stellarium

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- Easiest to use and navigate
- Most realistic rendering of the Sky
- Colour images of objects
- High frame rate, starves CPU (configurable)
- Telescope interface
  - Serial or TCP port
- Scripts for extension modules
- Linux, Windows, Android (paid)
- In Ubuntu repository

SkyChart/Cartes du Ciel

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- Most functionality and features
  - Darkness calculation, based on sun/moon rise/set times
  - Show me all objects on the screen
- Telescope interface
  - Direct support for certain models
  - INDI (more on that later)
- Written in Pascal
- Command Line Interface to control it, via exposed TCP port
- Scriptable (example on SourceForge)
- Linux, Windows
  - Download .deb, and install using gdebi

KStars

- Started as a KDE project
- Kind of ‘crude’
- More functionality in certain areas
  - Object position corrected for atmospheric refraction
- Telescope interface
  - INDI only (more on that later)
- Now works on Linux, Windows, Android and Mac
  - OK version in repository
  - Bleeding Edge version via PPA

INDI

- INDI (Instrument Neutral Device Interface)
- Drivers for:
  - Telescope Mounts
  - Motorized Focusers
  - Cameras (DSLR and specialized astro cameras)
  - Autoguiders
  - Domes
  - Dust caps
  - Weather Stations
- Part of the KStars project

Demos

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Planetariums with INDI

Second Real Scope

- Celestron C8, Schmidt Cassgrain
- Celestron CG5 Mount + iOptron GotoNova Goto Kit
- Canon EOS T4i DSLR
- Heated dew shield
- Laptop
- All used

Second Real Scope

- Used Celestron C8, Schmidt Cassgrain
- Used Celestron CG5 Mount + iOptron GotoNova Goto Kit
- Used Canon EOS T4i DSLR
- Used Laptop

Astrometry

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- Astrometry.Net
- Plate Solving
  - From the old ‘photographic plates’
  - Recognize the pattern of the stars in an image
  - Despite difference in magnification and field of view
- Linux software packages
- Web site
  - Online service
  - By uploading an image

Demos

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Astrometry Online

Ekos

- Telescope Automation Suite
  - Built on top of Kstars
  - Uses INDI
- Robotic operation
- Used in some professional observatories
- Functions
  - Alignment via Plate Solving (like magic!)
  - Focusing
  - Autoguiding
  - Capturing image sequence

Demos

Kstars with INDI and Ekos

Samples

Samples of images I took using Ekos/INDI

M51

- M51
- Whirlpool Galaxy
- 45 secs @ ISO 12800
- Interacting Now
- Face on
- Great sky and weather
- Crop

M81 and M82

- M81 Bode's
- M82 Cigar
- 45 secs @ ISO 6400
- Past Interaction
- Crop

M82

- M82 Cigar Galaxy
- 30 secs @ ISO 1600
- Dust lane
- Starburst region
- Crop

M101

- M101 Pinwheel
- 45 secs @ ISO 6400
- Face on
- Crop

M27

- M27
- Dumbell Nebula
- 45 secs @ ISO 3200
- Crop

M57

- M57
- Ring Nebula
- 45 secs @ ISO 1600
- Crop

M20

- M20
- Trifid Nebula
- Emission and Reflection
- 45 secs @ ISO 12800
- Nebulosity invisible to the eye
- Crop

Western Veil

- Supernova Remnant
- Invisible to the eye
- Crop

Alien Life Forms

Image Stacking

- The usual workflow for Astrophotography
  - Take many ‘subs’ (individual exposures)
  - Use software to align and stack them
  - Gather more photons
- Lxnstack
  - Python
- Siril
  - Written in C

FITS

- Image format
- Specific to astronomy usage
- Used in research, all image analysis, exchange, archiving, ...
- Used in Siril and Inxstack

AstroPy

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- Extensive package
- Many APIs
  - sky coordinates
  - Unit conversion
  - Modeling
  - Analysis
- Aimed at academia, professional astronomers, and astrophysicists

Debian Astro Blend

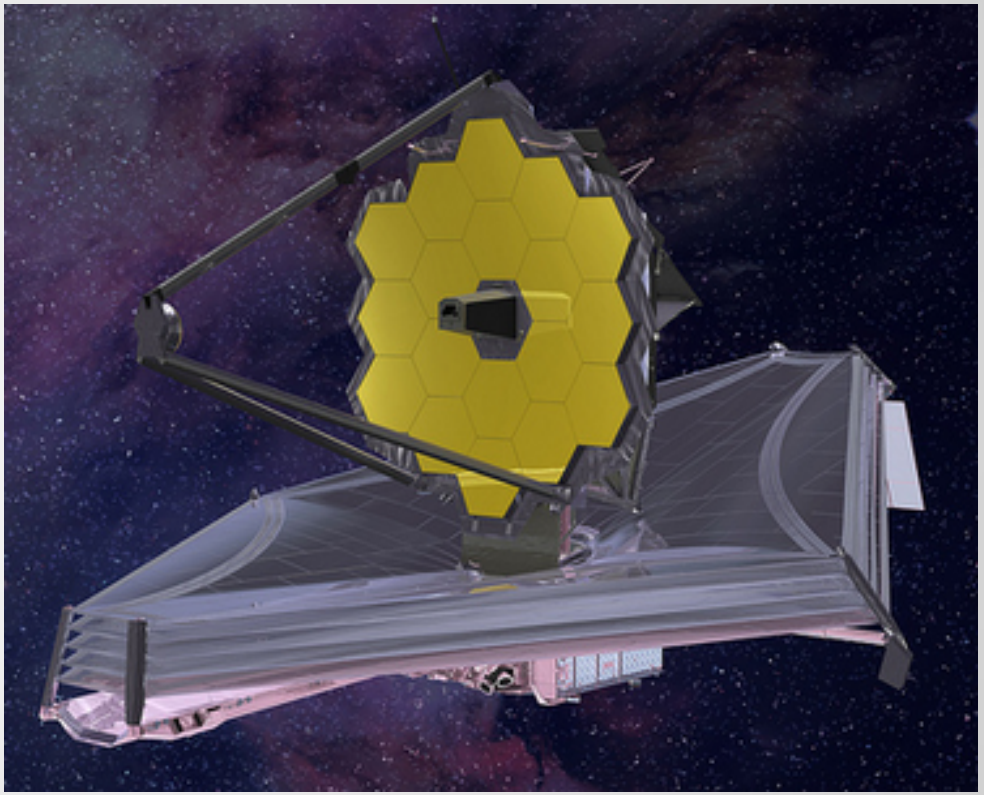
- A ‘blend’ of Debian
- Bundles a lot of astronomy applications

Future Plans

- Ability to observe in winter
  - Nights are longer, dark is earlier
  - Air is crisper
  - Different objects
  - Scope, camera and laptop outside
  - Pointing and capturing images
  - I only need to go outside for setup and focusing
- Not sure how low of a temperature the equipment can take
- Mount with more precision (less Periodic Error)

Dream Big!

- James Webb Telescope (JWT) launches 2018
- Which means Hubble Space Telescope will be decomissioned



Dream Big!

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I will be watching CraigsList!

Takeaways

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- There is a lot of functionality out there
- All are mature and functional
- Varying degrees of usability

Resources

- SkyChart/Cartes du Ciel
  - https://www.ap-i.net/skychart/en/start
- KStars (with Ekos included)
  - https://edu.kde.org/kstars/
  - Android KStars Lite in Google Play (Free)
- INDI
  - http://indilib.org/about/discover-indi.html
- Stellarium
  - http://stellarium.org/en/
  - Android app in Google Play ($)
- Astrometry
  - http://nova.astrometry.net/

Questions?

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Questions? Comments?